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Irrigation guide for
southern Alberta

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IRRIGATION GUIDE

for

Southern Alberta

1966

Prepared by

Alberta Department of Agriculture

Colonization Branch Irrigation Engineer

FOREWORD

The purpose of this guide is to indicate adapted crops and irrigation methods for various soils and slopes in Southern Alberta, together with specific recommendations for each method of irrigation shown. The guide is for the use of technical personnel working in the field of irrigation.

Consumptive use and frequency of irrigation are based on peak use requirements of the listed crops. Length of runs and size of streams are based on the average percent of each slope group and textural class.

It is hoped that the following material will be used by irrigation technicians so that designs of irrigation systems can more closely approach the requirements for high water application efficiencies.

Grateful appreciation is expressed to personnel of the Soils Section at the Lethbridge Research Station and to personnel of the Colonization Branch, Alberta Department of Agriculture, for their assistance in preparation and review of this guide.

Any errors or recommended changes should be brought to the attention of the Irrigation Engineer, Colonization Branch, Lethbridge, Alberta.

"Glen L. Steed", P. Eng.,
Irrigation Engineer.

The following decisions were made and used as a basis for developing the Guide:

1. The area covered by this Guide includes the lands lying within the borders of the Province of Alberta and south of the 52° parallel of latitude. General climatic data and crop moisture requirements and deficiencies are presented in figures 1,2,3,4, and Table I.

2. Major soils studied and included in this Guide are the Lethbridge and Chin series, the Coaldale series and the Carmangay and Cavendish series.

3. An analysis of single ring cylinder infiltrometer tests made in the area provided basic intake rates for irrigation design for each soil series. These rates were used directly for calculations involving flooding methods where the entire surface was covered, and provided a guide for estimating intake rates to be used for furrow, corrugations and sprinklers.

4. The water holding capacity of the soil as related to texture and a permeability rating was considered to be as follows:

Texture	Permeability	A.M. (in./ft.) #
Coarse (Cavendish-Carmangay)	Rapid	0.75 -1.25
Medium (Chin-Lethbridge)	Moderate	1.5 -2.0
Fine (Coaldale)	Slow	2.0 -2.5
Very Fine (Stirling)	Very Slow	2.0

# Available Moisture - The total quantity of water held in the soil that is available for plant use as determined by the difference between the field capacity and the permanent wilting point, may be expressed as a percentage or as inches per foot of depth of soil.

5. The following crops and related data were included in the Guide.

Crop	Row Spacing (in.)	Maximum Water Extraction Depth (ft.)	Maximum Stream Size g.p.m.	Allowable Moisture Depletion % T.R.A.M. ▲
Alfalfa	--	4 - 5 *	--	50
Grass	--	3	--	50
Grain	--	4	--	50
Potatoes	36	4	50	40
Corn	36	4	50	50
Sugar Beets	22	4	25	50
Beans	30	4	25	50
Peas	--	3	--	50

* The larger depth applies where alfalfa is grown on light soil, e.g. Cavendish or Carmangay soil.

▲ Total Readily Available Moisture.

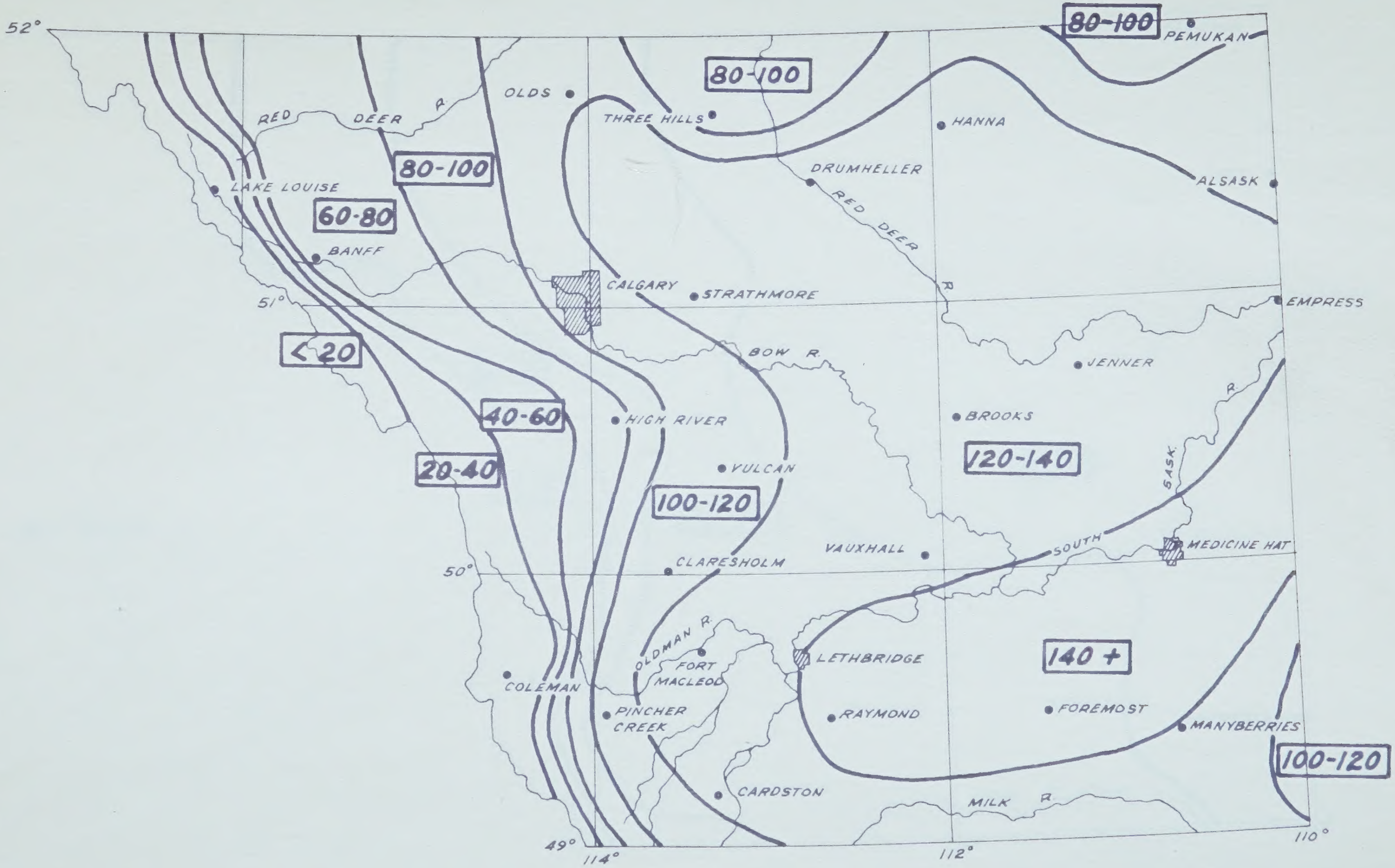

Figure 1. MAP SHOWING GROWING SEASON (DAYS) FOR SOUTHERN ALBERTA.

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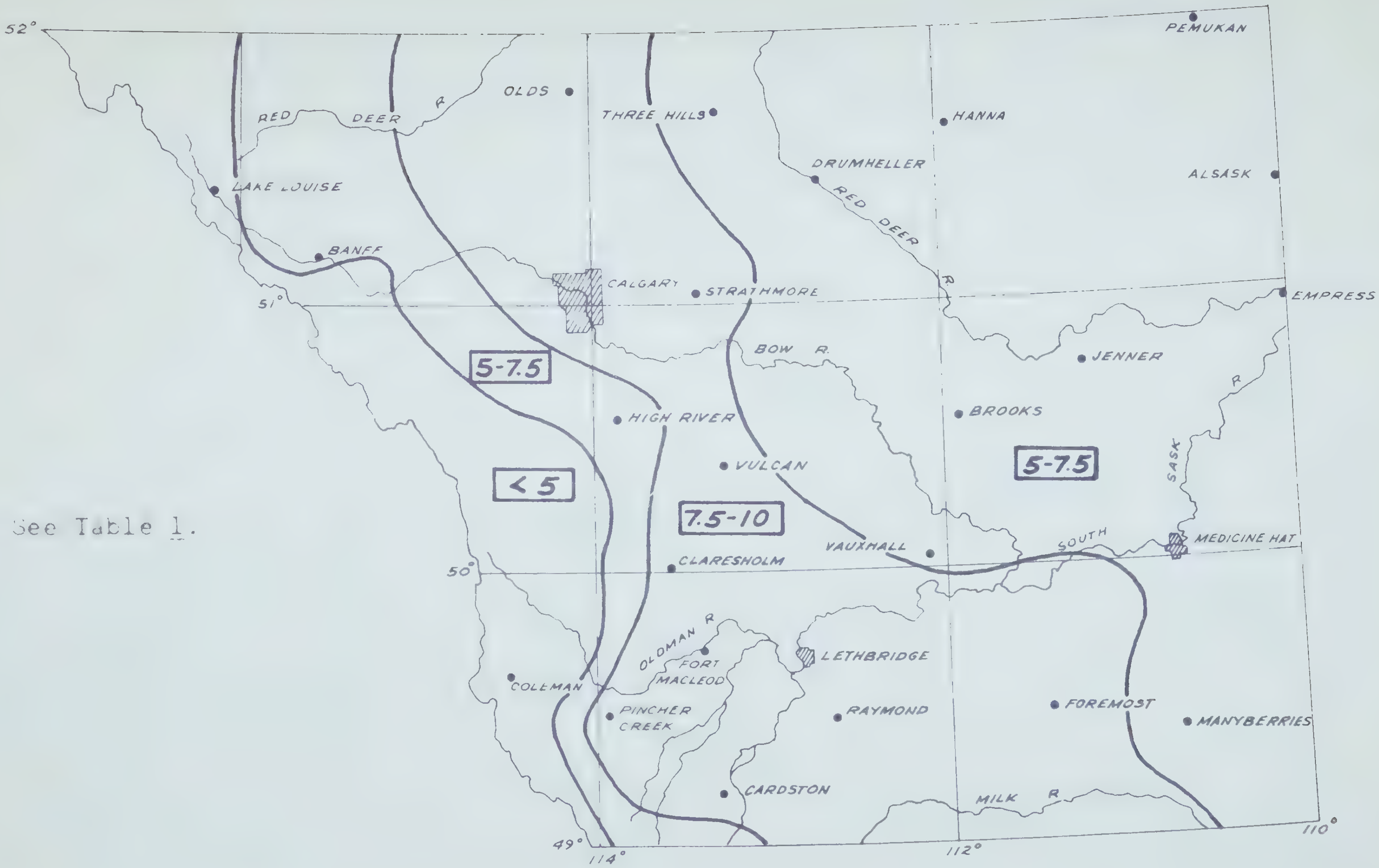
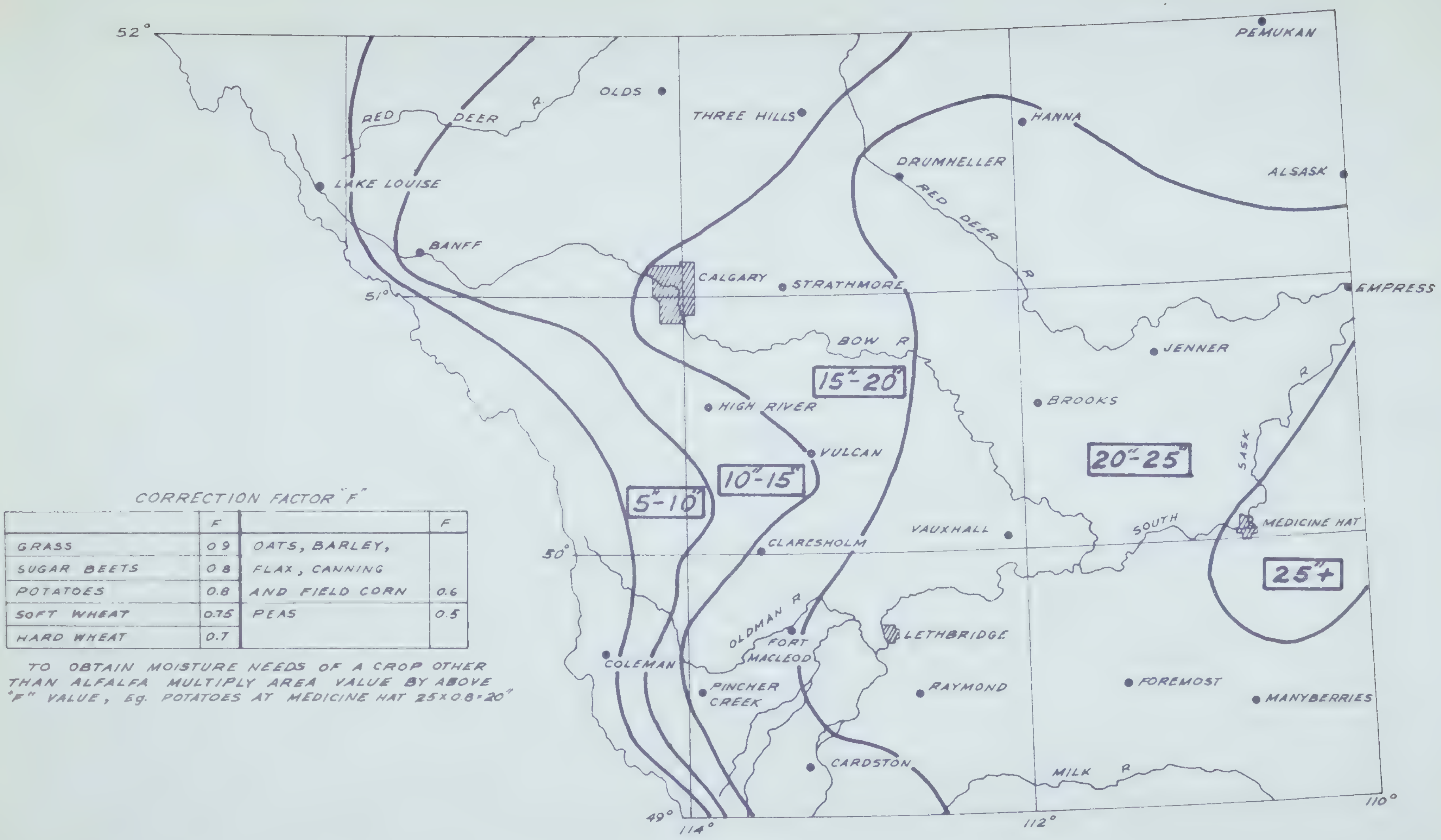


N.B. See Table 1.

Figure 2. MAP SHOWING GROWING SEASON PRECIPITATION FOR SOUTHERN ALBERTA - Long Time Averages



CORRECTION FACTOR "F"

	F		F
GRASS	0.9	OATS, BARLEY,	
SUGAR BEETS	0.8	FLAX, CANNING	
POTATOES	0.8	AND FIELD CORN	0.6
SOFT WHEAT	0.75	PEAS	0.5
HARD WHEAT	0.7		

TO OBTAIN MOISTURE NEEDS OF A CROP OTHER THAN ALFALFA MULTIPLY AREA VALUE BY ABOVE "F" VALUE, Eg. POTATOES AT MEDICINE HAT 25×0.8=20"

Figure 3. MAP SHOWING CONSUMPTIVE USE VALUES FOR ALFALFA.

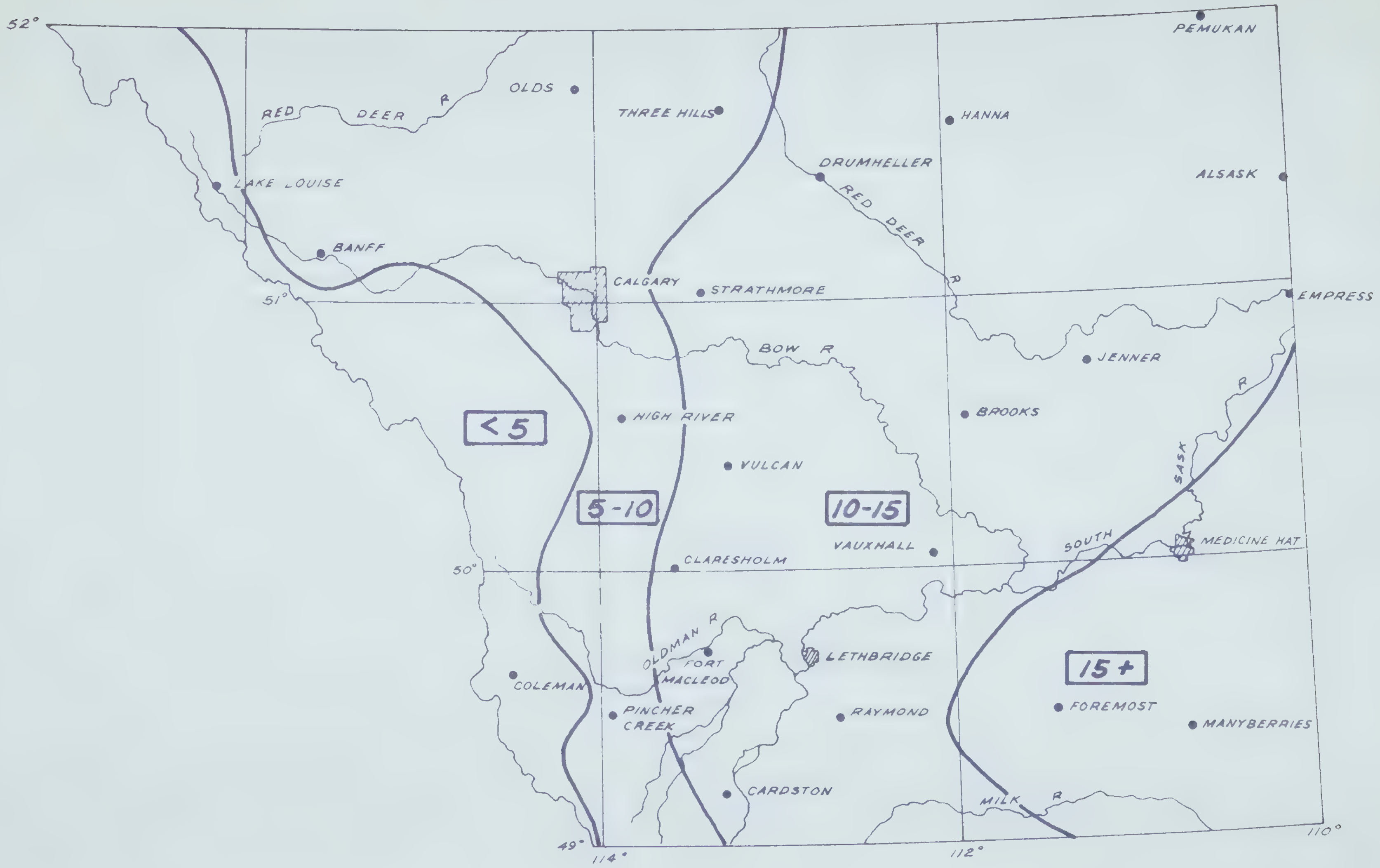


Figure 4. MAP SHOWING GROWING SEASON MOISTURE DEFICIT FOR ALFALFA.

TABLE I -Climatic Summary

Location	Growing Season Length (days)	Growing Season Precipitation (Inches)	Elevation (ft.)	Alfalfa Moisture Needs * (in.)
Alsask	115	6.21	2300	19.0
Banff	65	6.19	4583	14.3
Brooks	139	7.38	2487	22.2
Caldwell	114	8.57	4000	17.4
Calgary	110	8.88	3428	17.4
Cardston	123	7.85	3826	19.2
Carway	107	7.05	4000	16.3
Cowley	97	6.80	3878	15.4
Drumheller	132	7.43	2255	21.7
Empress	135	8.24	2000	22.2
Foremost	147	8.51	2922	23.9
Fort Macleod	141	10.00	3128	22.8
Gleichen	121	7.37	2952	19.5
Hanna	123	7.32	2677	20.1
High River	69	5.21	3800	11.1
Jenner	125	5.91	2480	20.5
Lethbridge	140	8.91	2940	22.1
Manyberries	140	6.19	3000	22.8
Medicine Hat	152	7.96	2365	25.1
Olds	116	9.73	3413	17.9
Pincher Creek	117	9.29	3758	18.0
Raymond	143	8.49	3123	22.5
Strathmore	125	8.55	3160	19.7
Suffield	122	7.36	2543	20.6
Three Hills	83	6.31	2936	14.0
Vauxhall	131	6.87	2555	19.8

* Determined by Blaney - Criddle Method.

6. Recommended peak consumptive use rates in inches per day are listed in Table 2. The values are those determined by the Irrigation Gauge program in each area.

7. The following slope groupings were made for irrigation recommendations:

Slope	Computed As
0.2 - 0.5%	0.4%
0.5 - 1.0%	0.75%
1.0 - 2.0%	1.5%
2.0 - 4.0%	3.0%
4.0 - 8.0%	6.0%

8. Borders were recommended on all soils on slopes up to 2% for alfalfa, small grains, grass, legumes. Border widths up to 50 feet were recommended on slopes up to .5%, up to 40 feet for slopes to 2%, and unit streams were computed from curves derived from evaluation tests made on lands in the Guide area (see figure 6). Table 3 presents the maximum border widths and maximum stream sizes for various slopes. The values were for a 0.5% slope and were modified by applying the following factors obtained from Figure 7:

Slope	Factor
.2 - .5%	x 1.00
.5 - 1 %	x 0.9
1 - 2 %	x 0.8

The following design efficiencies were recommended:

	Intake Rate (in./hr.)		
Slope	0.2 - 0.5,	0.5 - 0.8,	0.8 - 1.5
.2 - .5%	70	80	75
0.5 - 2 %	65	75	70

TABLE 2 - Peak Use Rate for Zones A, B, and C (See Figure 5)

Crop	Net Irrigation Application (Inches)								
	2"			3"			4"		
	A	B	C	A	B	C	A	B	C
Alfalfa	.26	.24	.23	.25	.23	.22	.23	.21	.20
Corn	.24	.22	.21	.22	.20	.19	.21	.19	.18
Grass	.26	.24	.23	.25	.23	.22	.23	.21	.20
Small Grain	.25	.22	.21	.24	.21	.20	.23	.20	.19
Potatoes	.24	.22	.21	.23	.21	.20	.22	.20	.19
Sugar Beets	.25	.23	.22	.24	.22	.21	.23	.21	.19
Beans	.24	.23	.21	.23	.22	.21	.22	.20	.19
Peas	.25	.22	.21	.24	.21	.20	.23	.20	.19

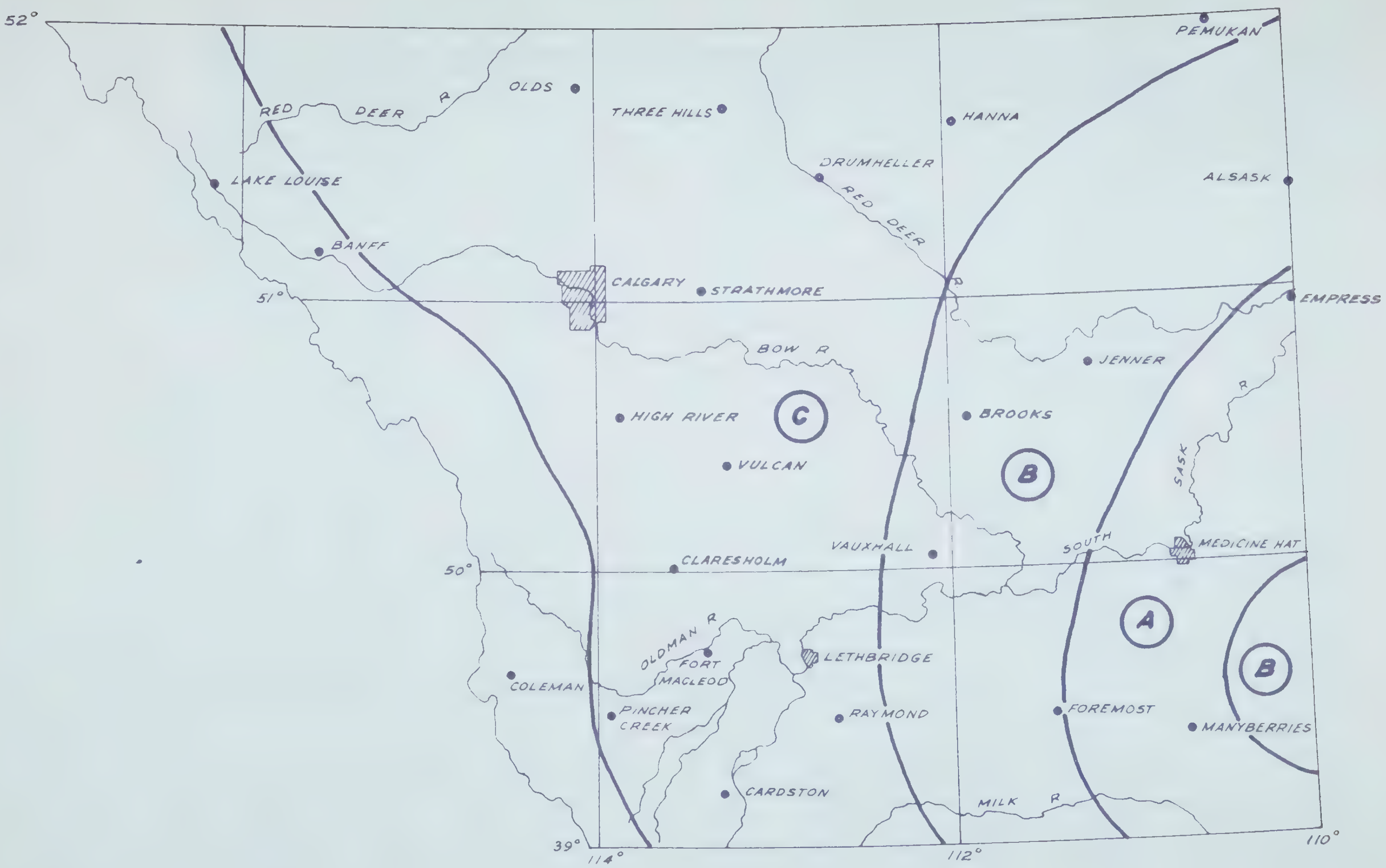


Figure 5. MAP SHOWING PEAK CONSUMPTIVE USE ZONES FOR SOUTHERN ALBERTA.

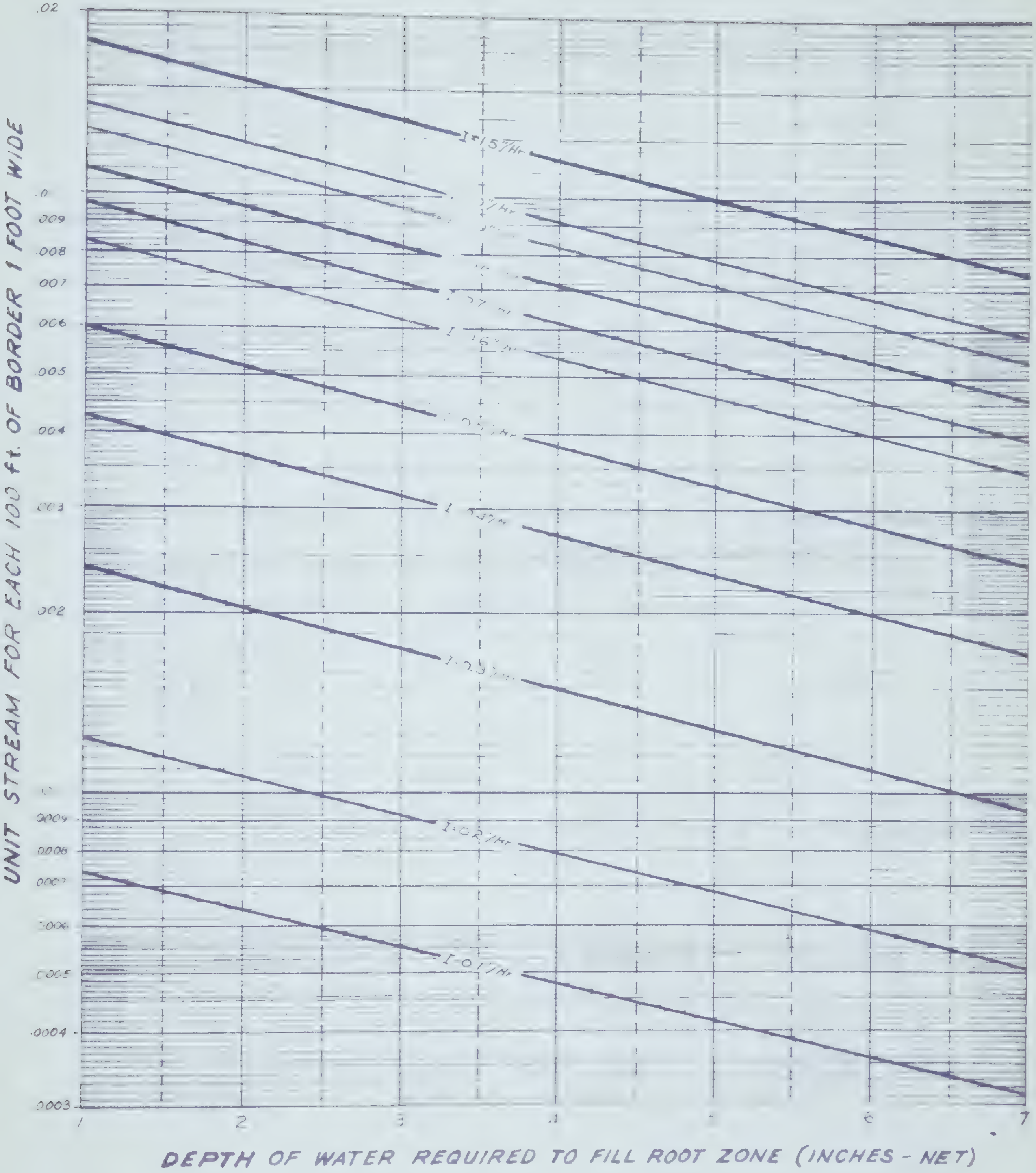


Figure 6. Curves for estimating border stream size.

TABLE 3 - MAXIMUM ALLOWABLE BORDER WIDTH AND STREAM SIZE AS AFFECTED BY SLOPE

Downfield Slope %	Maximum Q c.f.s./ft. of border width	N = 0 to N = 2		N = 3		N = 4		N = 5	
		Maximum Border Width (ft.)	Maximum Stream Size (c.f.s.)	Maximum Border Width (ft.)	Maximum Stream Size (c.f.s.)	Maximum Border Width (ft.)	Maximum Stream Size (c.f.s.)	Maximum Border Width (ft.)	Maximum Stream Size (c.f.s.)
0.3	0.150	50	7.0	33 *	6.0				
0.4	0.120	50	6.0	33	4.8	25 *	4.0		
0.5	0.100	50	5.0	33	4.0	25	3.3	25 *	2.5
0.6	0.086	50	4.3	33	2.8	25	2.8	20	2.1
0.7	0.077	40	3.1	33	2.5	25	1.9	20	1.9
0.8	0.070	40	2.8	33	2.3	25	1.75	20	1.4
0.9	0.064	40	2.6	33	2.1	25	1.6	20	1.3
1.0	0.060	40	2.4	33	2.0	25	1.5	20	1.2
1.5	0.043	33	1.4	33	1.4	25	1.1	20	0.9
2.0	0.035	33	1.2	25	0.9	25	0.9	20	0.7

Slopes greater than 2.0% not recommended but can be used for pasture with 16 foot borders.

* Where downfield slope (as indicated in column 1) is not continuous but varies less to slope, then slightly wider borders could be used.

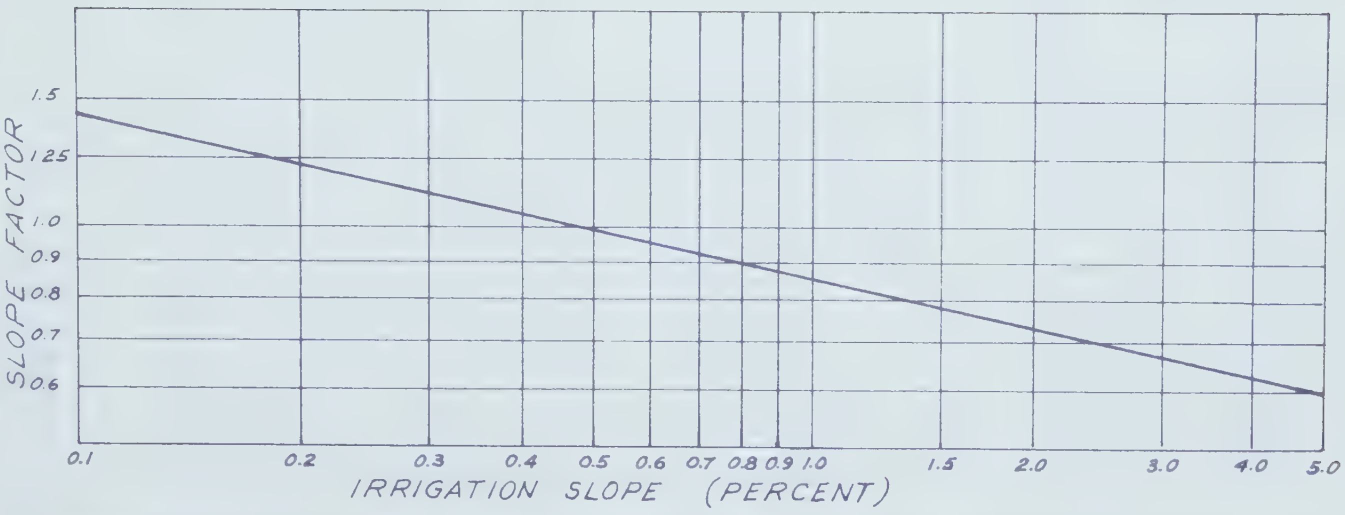


Figure 7. FACTORS FOR USE IN ADJUSTING UNIT STREAMS FOR SLOPES OTHER THAN 0.5 PERCENT

Reference: Methods for Evaluating Irrigation Systems Handbook 82 S.C.S. U.S.D.A.

Because of the difficulty in getting water spread between border dykes, borders were not recommended, when the unit stream was less than that as determined by figure 8 for a specific slope.

Maximum length of run for borders was based on a maximum depth of flow of 0.4 feet or a length that would require an erosive stream as determined by Table 3 from Handbook 82 of the Soil Conservation Service. (1)

The maximum length recommended in any instance did not exceed 2640 feet. Time of irrigation was computed as the time required to apply the gross irrigation application into a unit area with the unit stream.

$$T = 0.00232 \frac{D}{q}$$

Where T = time in hours
D = gross application in inches
q = unit stream in c.f.s.
Unit Stream = stream size needed for each strip of land 1 ft. wide X 100 ft. long.

9. Furrows were recommended for all row crops on fine through coarse textured soils on slopes up to 4%.

Maximum stream sizes in furrows were based on the capacities given in paragraph 5 or upon the maximum non-erosive stream, whichever was smaller. Length of runs were determined by use of the irrigation slide rule. Intake rates for furrows, as determined by preliminary field tests, showed good agreement with a tentative correlation, prepared by the Lincoln Engineering and Watershed Planning Unit S.C.S. (Lincoln, Nebraska), and based on stream size and the basic intake rate, as determined by cylinder infiltrometers. The intake rates for furrows were determined from field tests and from the tables prepared by the S.C.S. Lincoln Engineering and Watershed Planning Unit. Time of application was computed from the irrigation slide rule using the net irrigation application. The following design efficiencies were recommended:

Slope	Field Efficiency
.2 - .5%	70%
.5 - 1 %	65%
1 - 2 %	60%
2 - 4 %	55%

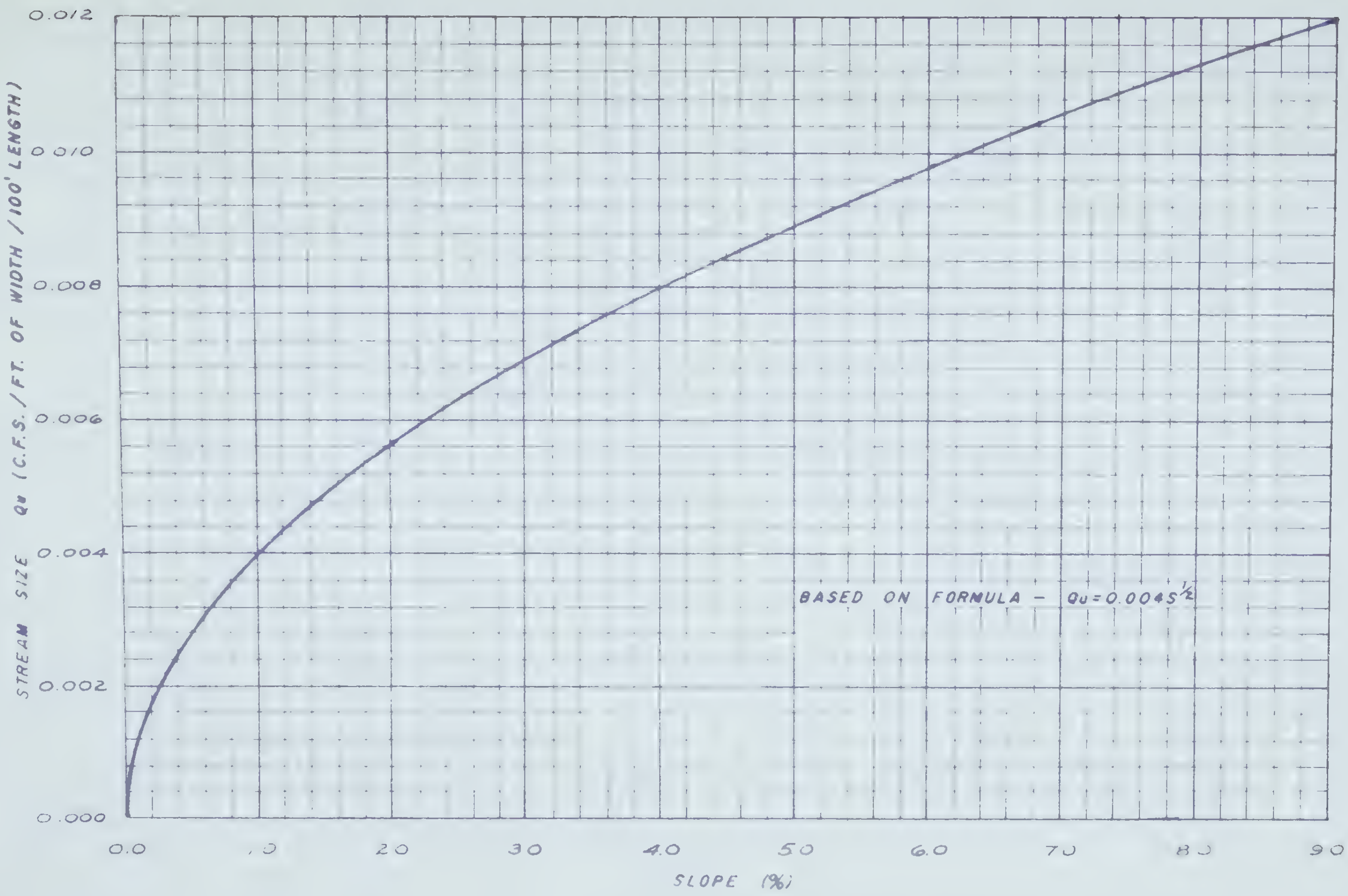


Figure 8 - Minimum Unit Stream for Covering Border.

10. Corrugations are small furrows, recommended for use on alfalfa, small grains, grass, and legumes on fine to moderately coarse textured soils on slopes from 0.5 to 8%. It was felt that normally a maximum of 13 g.p.m. stream size would be all that the general corrugation could carry. Length of runs were computed from the irrigation slide rule. The following corrugation spacings were recommended:

Net Depth of Irrigation	Soil Texture Fine	 Medium	 Coarse
2"	20	18	18
3"	24	20	20
4"	30	24	24

Time of irrigation was computed from the irrigation slide rule, using the net irrigation application. The following design field efficiencies were recommended:

Slope	Efficiency
0.5 - 1.0%	65
1.0 - 2.0%	60
2.0 - 4.0%	55
4.0 - 8.0%	50

Figure 9 presents the stream sizes and time of application for various slopes, lengths of runs, and infiltrations. Where the corrugation cross-sectional area is greater than 0.35 sq. ft., then furrow criteria should be used for design.

11. Contour ditches were recommended for close grown crops on fine to medium textured soils on slopes between 1 and 6%. On slopes from 6 to 8%, contour ditches were recommended for grass crops on the fine to medium textured soils. Close grown crops on moderately coarse soils could be irrigated by this method on slopes up to 6%, whereas on coarse textured soils on slopes from 1 to 4%. The following spacings were recommended:

Texture	0 - 2%	2 - 4%	4 - 8%
Fine	250'	200'	125'
Medium	175'	125'	75'
Coarse	150'	100'	50'

The following design efficiencies were recommended:

Slope	Basic Intake Rate (in./hr.) 0.5"/hr.	 0.5 - 1.5"/hr.
1 - 4%	60%	55%
4 - 8%	50%	50%

Time of application was taken from figure 10.

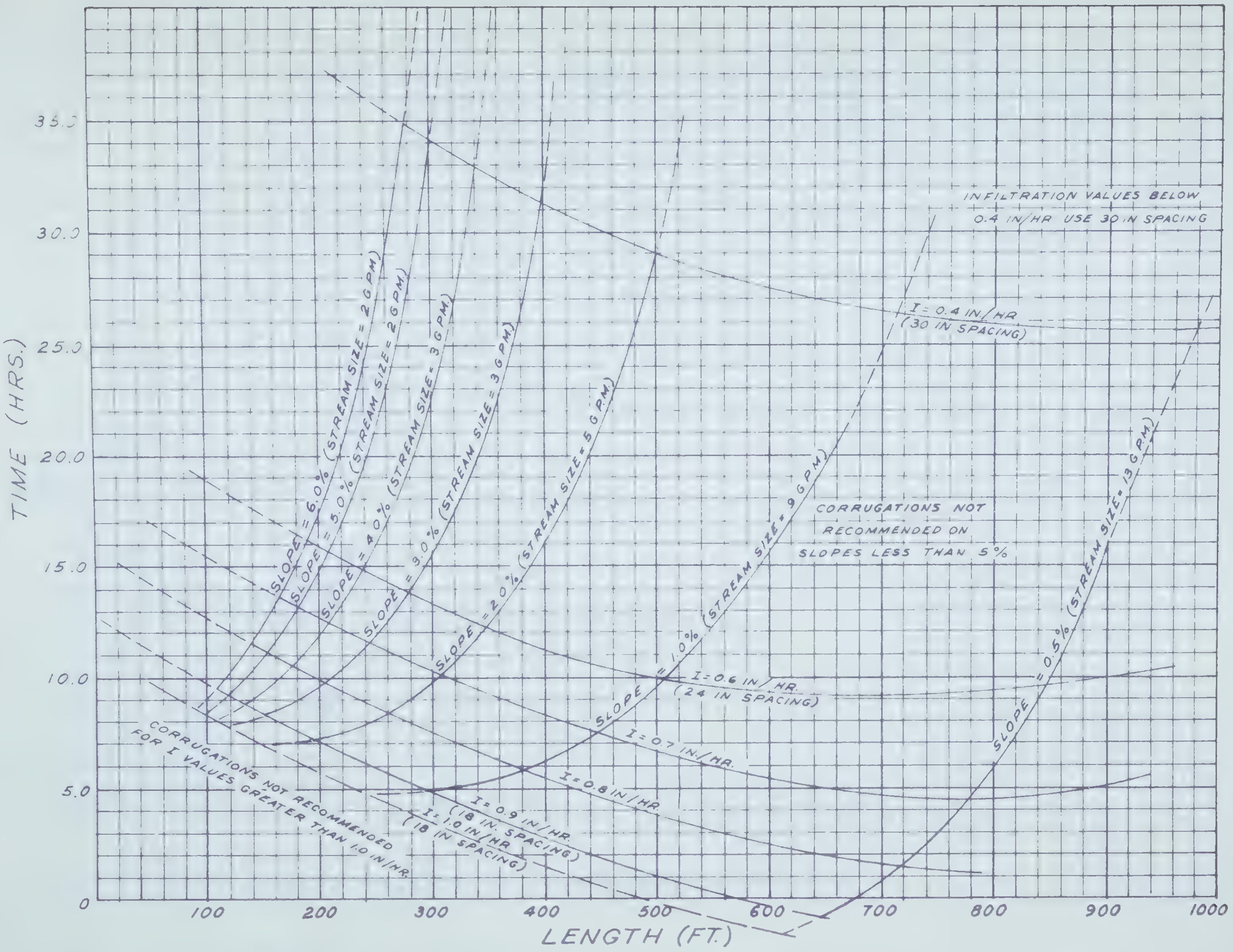
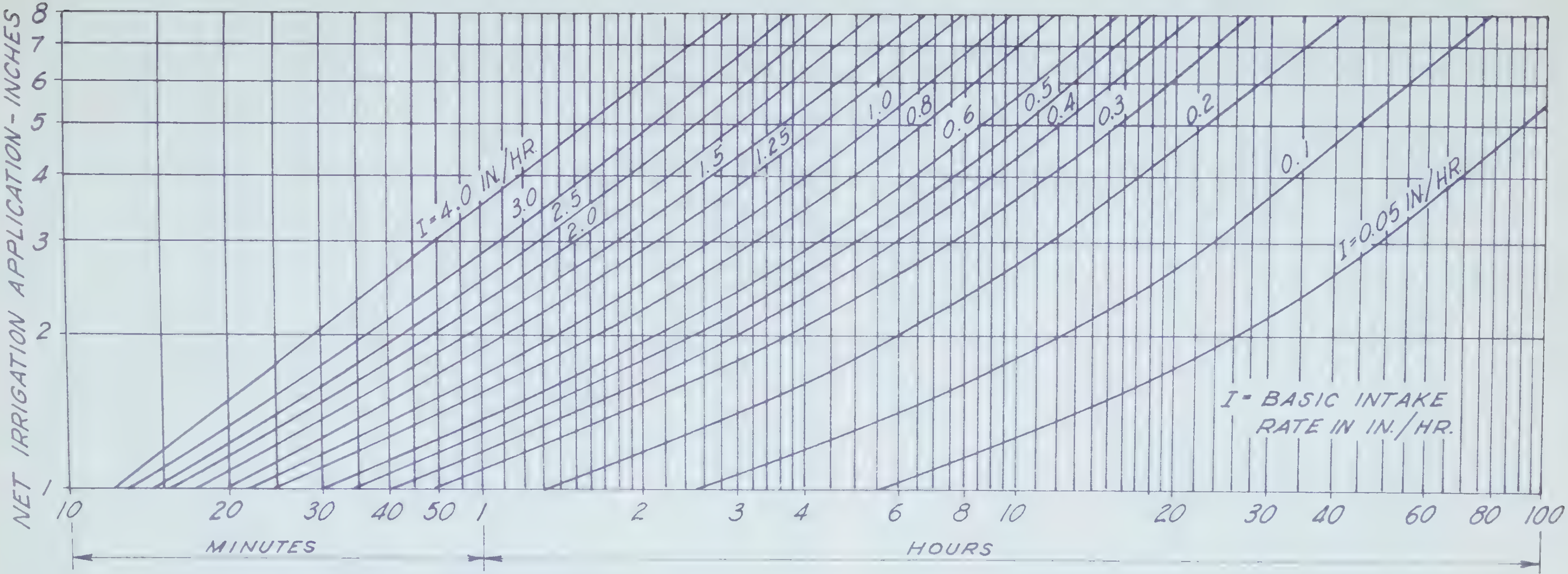


Figure 9 - Corrugation Recommendation.



EST. DEEP PERCOLATION LOSSES

I	% LOSS	I	% LOSS
0.05	3	1.0	20
0.1	5	1.25	22
0.2	8	1.5	24
0.3	10	2.0	28
0.4	12	2.5	31
0.5	14	3.0	33
0.6	16	4.0	37
0.8	18		

Figure 10 - CONTOUR DITCH IRRIGATION TIME, Nov. 1954

Reference: U.S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

12. Sprinklers were recommended for all crops on slopes between 0 and 8% on soils with sprinkler intake rates of 0.2"/hr. or higher. On slopes over 4% on soils with low intake rates, pure alfalfa stands were not recommended.

Intake rates were estimated based on a knowledge of soil characteristics when tested with cylinder infiltrometers. The following design efficiencies were recommended (wind affects excluded):

Net Irrigation Application	Sprinkler Application Rate (in/hr) 0.2 - 0.5 *	 0.5 and over
under 3"	65%	70%
3" and over	70%	75%

* Where a sprinkler system is operated at night for at least 50% of the time of a set, then the indicated efficiencies can be increased by 5%.

13. To provide field personnel with a knowledge of safe maximum values of mean water velocities safe against erosion in ditches, Table 4 is included.

The tabulated values in Table 4 are of mean velocity, which practice has shown to be maximum values for safety against erosion, or values obtained on canals, in which velocities which originally were excessive have been reduced to a safe value by the flattening of the grade resulting from erosion. Mean velocities are given, as these are generally used in computations. Bottom velocity is approximately 75% of the mean velocity.

14. The need for technicians to have a good understanding of moisture conditions when discussing irrigations with farmers prompted the inclusion of the "Practical Interpretation Chart for Soil Moisture" (Table 5). This chart should not be advocated as a guide for scheduling irrigations but for use only by the Irrigation Technician in discussing present moisture conditions. The Irrigation Gauge is available and should be presented as the method of scheduling irrigations.

15. To provide field personnel with an indication of accumulative infiltration curves for the soil series studied, figures 11, 12, 13, 14, and 15 are included in the Guide.

The indicated times are for a 100% efficiency and should be divided by the proper efficiency value to determine the full time required to apply a required amount.

The unit streams are general amounts for use with the indicated soil texture and depth of water to be applied.

16. Table 6 is arranged so that any known AM values may be used. This table shows the TRAM value for various root zone soil profiles. To use the table, the effective root zone depth and the depth at which the soil texture changes occur must be known or assumed.

TABLE 4 - Maximum Non-Erosive Streams for Ditches *

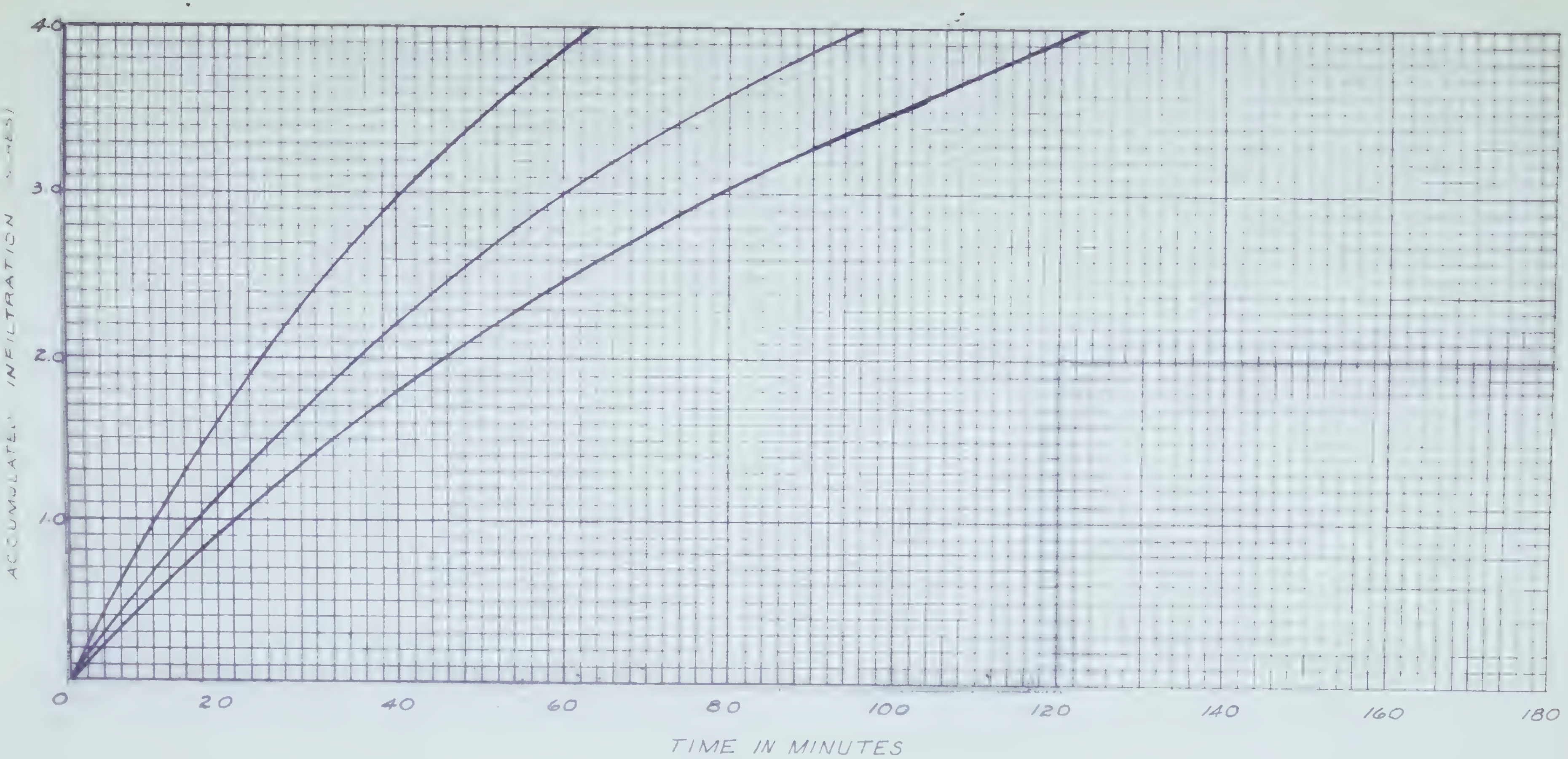
Material	Value of Manning's n	Velocity in Feet per Second		Velocity in Meters per Second	
		Clear Water	Water Transporting Colloidal Silts	Clear Water	Water Transporting Colloidal Silts
Fine Sand, colloidal	0.020	1.31	2.62	0.4	0.8
Sandy loam, non-colloidal	0.020	1.64	2.62	0.5	0.8
Silt loam, non-colloidal	0.020	1.97	2.96	0.6	0.9
Alluvial Silts, non-colloidal	0.020	1.97	3.62	0.6	1.1
Ordinary firm loam	0.020	2.62	3.62	0.8	1.1
Volcanic ash	0.020	2.62	3.62	0.8	1.1
Stiff clay, very colloidal	0.025	3.62	4.93	1.1	1.5
Alluvial silts, colloidal	0.025	3.62	4.93	1.1	1.5
Shales and hardpans	0.025	5.90	5.90	1.8	1.8
Fine gravel	0.020	2.62	4.93	0.8	1.5
Graded loam to cobbles when non-colloidal	0.030	3.62	4.93	1.1	1.5
Graded silts to cobbles when colloidal	0.030	3.94	5.57	1.2	1.7
Coarse gravel, non-colloidal	0.025	3.94	5.90	1.2	1.8
Cobbles and shingles	0.035	4.93	5.57	1.5	1.7

* Irrigation Principles and Practices- 2nd Edition - Israelson, O.W. and Hansen, V.

TABLE 5 - PRACTICAL INTERPRETATION CHART FOR SOIL MOISTURE

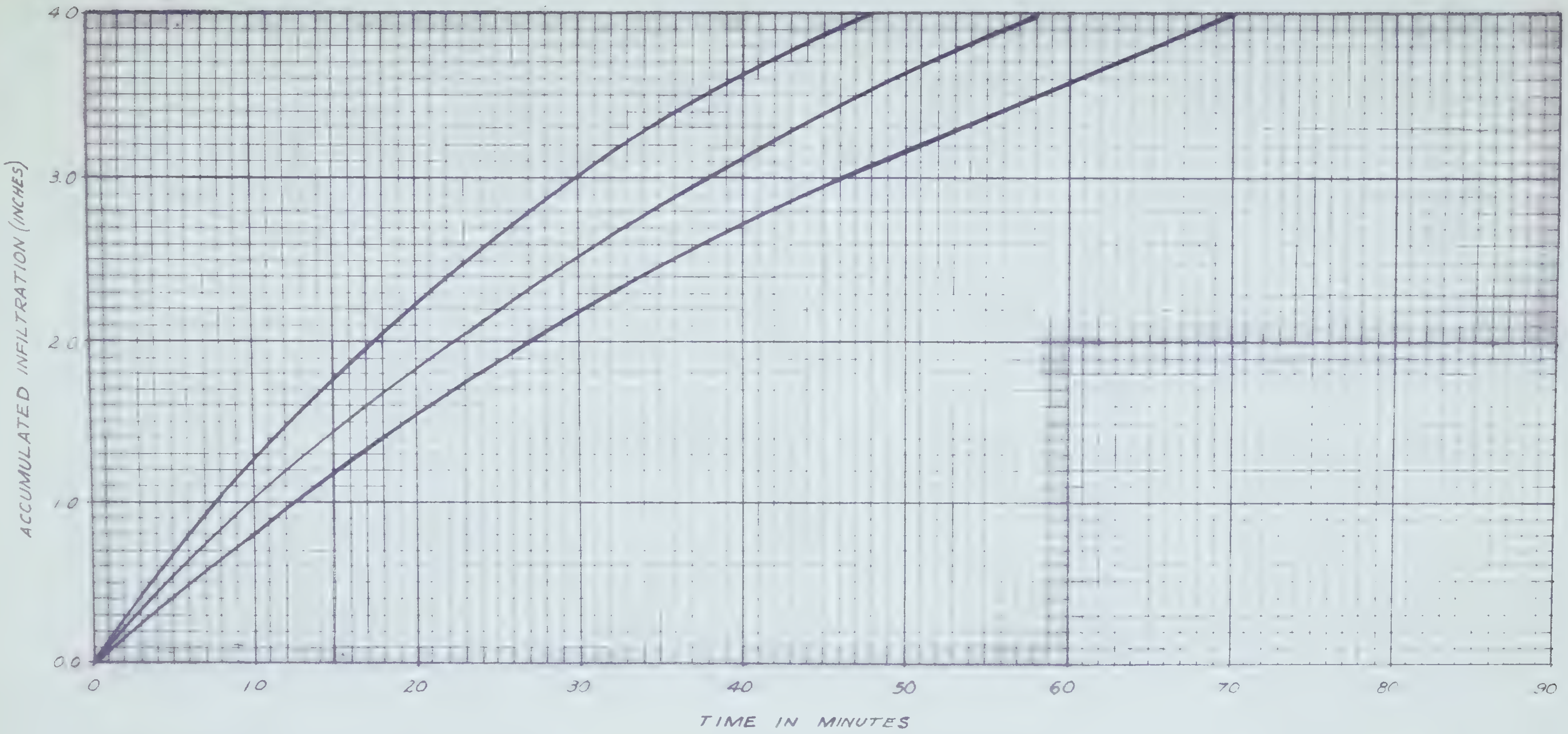
ercent of vailable oisture emaining	Feel or appearance of soils			
	Coarse	Light	Medium	Heavy and very heavy
0	Dry, loose, single-grained, flows through fingers.	Dry, loose, flows through fingers.	Powdery, dry, sometimes slightly crusted but easily breaks down into powdery condition.	Hard, baked, cracked, sometimes has loose crumbs on surface.
0 or less	Still appears to be dry; will not form a ball with pressure. *	Still appears to be dry; will not form a ball. *	Somewhat crumbly, but will hold together from pressure.	Somewhat pliable, will ball under pressure. *
0 to 75	Same as Coarse Texture under 50 or less.	Tends to ball under pressure but seldom will hold together.	Forms a ball, * somewhat plastic; will sometimes slick slightly with pressure.	Forms a ball; will ribbon out between thumb and forefinger.
75 to field capacity	Tends to stick together slightly, sometimes forms a very weak ball.	Forms weak ball, breaks easily, will not slick.	Forms a ball and is very pliable; slicks readily if relatively high in clay.	Easily ribbons out between fingers; has a slick feeling.
At field capacity	Upon squeezing, no free water appears on soil but wet outline of ball is left on hand.	Same as Coarse.	Same as Coarse.	Same as Coarse.
Above field capacity	Free water appears when soil is bounced in hand.	Free water will be released with kneading.	Can squeeze out free water.	Puddles and free water forms on surface.

* Ball is formed by squeezing a handful of soil very firmly with fingers.



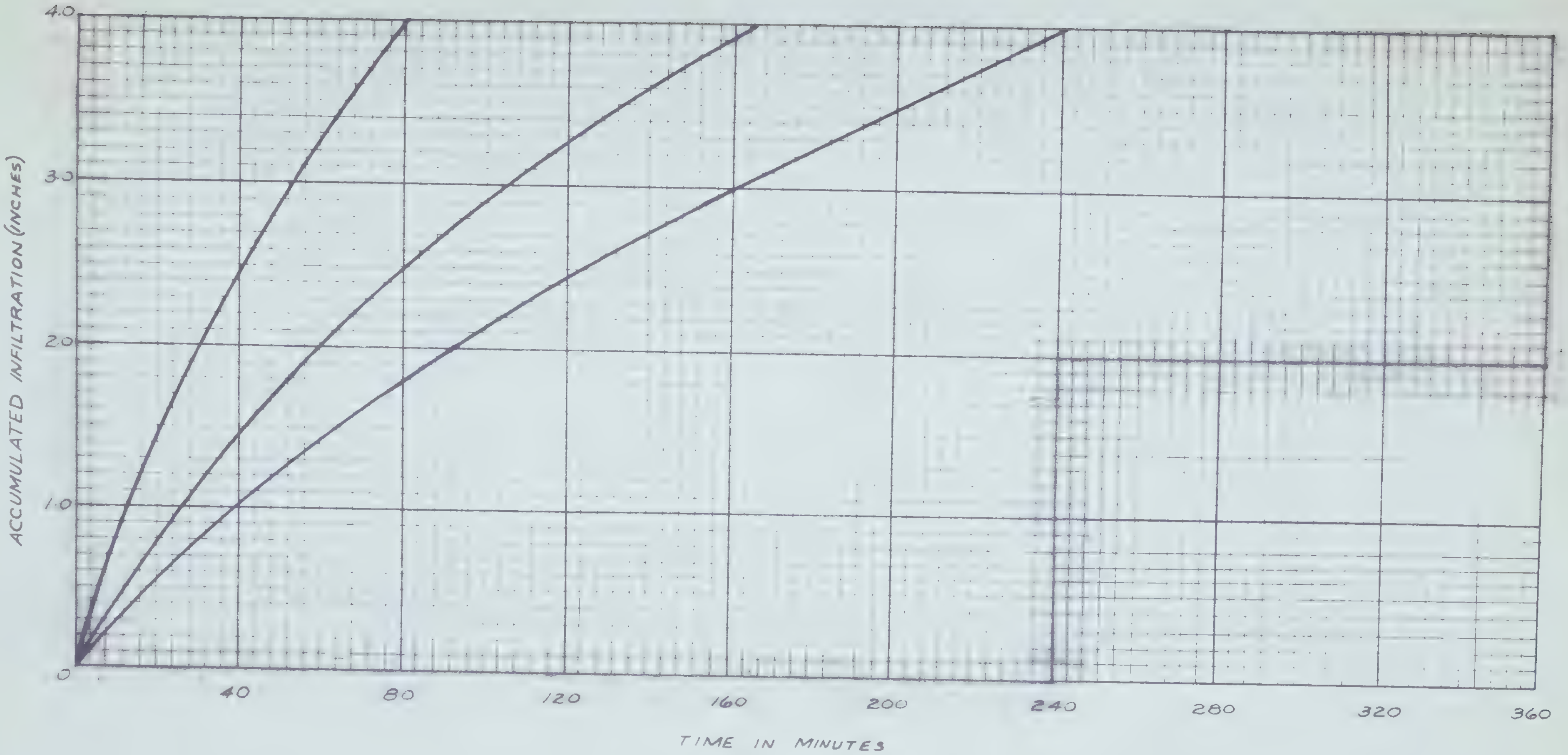
CHIN SOIL												
	COARSE TEXTURED				MEDIUM TEXTURED				FINE TEXTURED			
DEPTH	1"	2"	3"	4"	1"	2"	3"	4"	1"	2"	3	4"
TIME (MIN)	10.0	23.0	40.0	63.0	5.0	35.0	60.0	96.0	20.0	45.0	78.0	123.0
Qu.	.0135	.0118	.010	.0088	.009	.0078	.0067	.0057	.007	.0061	.0052	.0045

Figure 11. Accumulated Infiltration Curves, Time and Unit Stream for a Chin Soil.



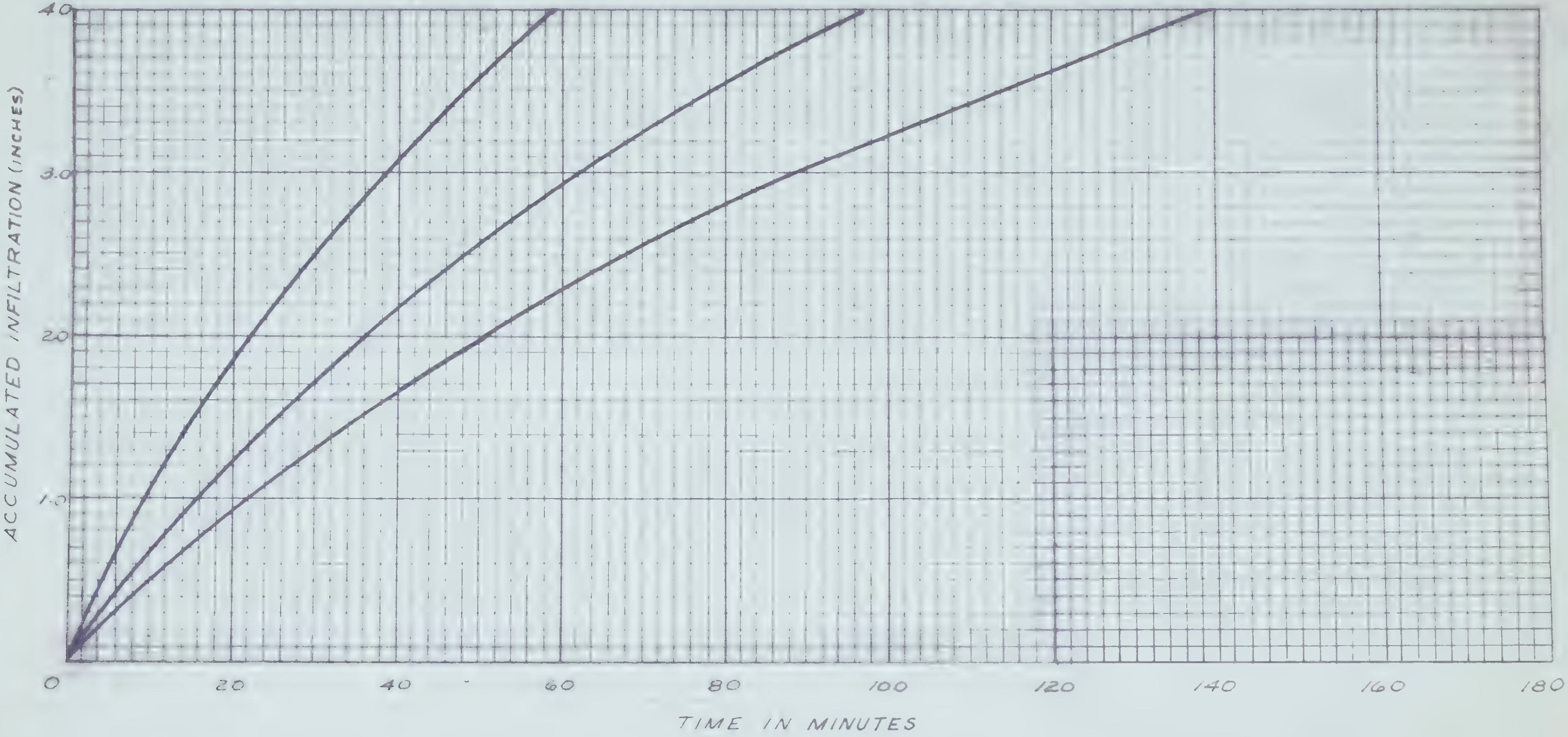
CAVENDISH SOIL												
	COARSE TEXTURED				MEDIUM TEXTURED				FINE TEXTURED			
DEPTH	1"	2"	3"	4"	1"	2"	3"	4"	1"	2"	3"	4"
TIME (MIN.)	7.5	18	30	48	9.5	22	38	58	13	27	46	70
Qu	0.018	0.0155	0.0135	0.0115	0.0145	0.0127	0.0110	0.0095	0.115	0.01	0.0087	0.0075

Figure 12 - Accumulated Infiltration Curves, Time and Unit Streams for a Cavendish Soil.



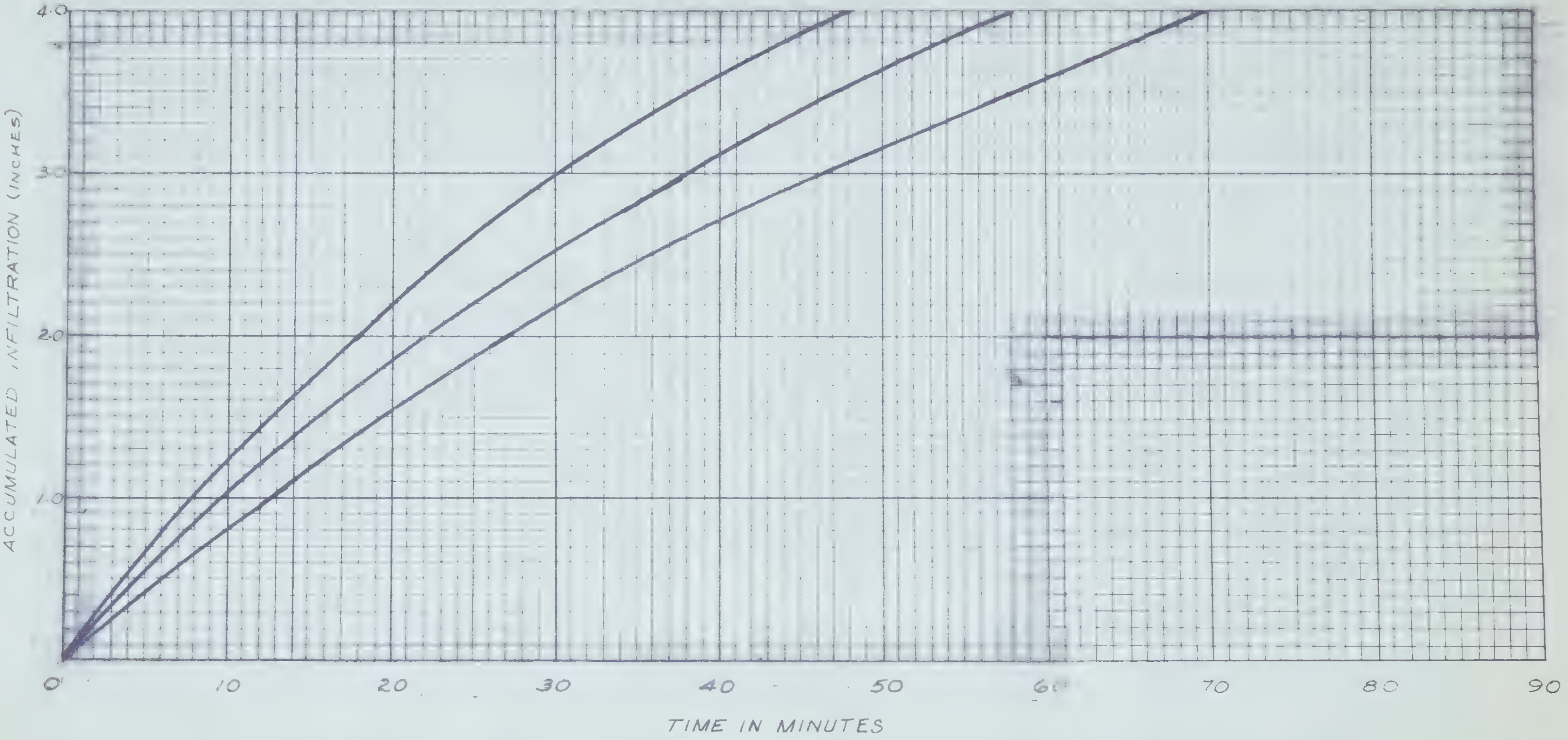
COALDALE SOIL												
	COARSE TEXTURED				MEDIUM TEXTURED				FINE TEXTURED			
DEPTH	1	2	3	4"	1	2"	3	4"	1"	2"	3"	4"
TIME (MIN)	26	300	53.0	80.4	260	600	105.6	166.2	39.6	93.0	160.8	241.8
Qu	.011	.0092	.0079	.0069	.0053	.0046	.0039	.0033	.0035	.0030	.0026	.0022

Figure 13. Accumulated Infiltration Curves, Time and Unit Streams for a Coaldale Soil.



	LETHBRIDGE SOIL											
	COARSE TEXTURED				MEDIUM TEXTURED				FINE TEXTURED			
DEPTH	1"	2"	3"	4"	1"	2"	3"	4"	1"	2"	3"	4"
TIME (MIN)	9	22.0	38.5	59.0	15.5	30.0	62.4	96.6	21.6	50.6	88.8	139.2
Qu	[illegible]	.0125	[illegible]	.0094	.009	.0078	.0067	.0057	.0064	.0055	.0047	.0040

Figure 14. Accumulated Infiltration Curves, Time and Unit Streams for a Lethbridge Soil.



CARMANGAY SOIL												
	COARSE TEXTURED				MEDIUM TEXTURED				FINE TEXTURED			
DEPTH	1"	2"	3"	4"	1"	2"	3"	4"	1"	2"	3"	4"
TIME (MIN)	7.5	18.0	30.0	48.0	9.5	22.0	38.0	58.0	13.0	27.0	46.0	70.0
Qu	.018	.0155	.0135	.0115	.0145	.0127	.011	.0095	.0115	.01	.0087	.0075

Figure 15. Accumulated Infiltration Curves, Time and Unit Streams for a Carmangay Soil.

TABLE 6 Total Readily Avaible Moisture (TRAM), inches of water *

(For Root Zone Profile as Limited by Texture of Soil Layers)

Soil Layers	Available moisture (AM) in inches per foot									
	2.4	2.2	2.0	1.8	1.6	1.4	1.2	1.0	0.8	0.6
				12-in root zone						
0- 6 in	1.7	1.6	1.4	1.3	1.1	1.0	0.9	0.7	0.6	0.4
6 -12 in					-	2.3	2.0	1.7	1.3	1.0
				18-in root zone						
0 - 6 in	2.4	2.2	2.0	1.8	1.6	1.4	1.2	1.0	0.8	0.6
6 -12 in	3.5	3.2	3.0	2.7	2.4	2.1	1.8	1.5	1.2	0.9
12-18 in								-	2.7	2.0
				24-in root zone						
0 - 6 in	3.0	2.8	2.5	2.3	2.0	1.8	1.5	1.3	1.0	0.8
6 -12 in	4.0	3.7	3.3	3.0	2.7	2.3	2.0	1.7	1.3	1.0
12-18 in			-	4.5	4.0	3.5	3.0	2.5	2.0	1.5
18-24 in									-	3.0
				30-in root zone						
0 - 6 in	3.6	3.3	3.0	2.7	2.4	2.1	1.8	1.5	1.2	0.9
6 -12 in	4.6	4.2	3.8	3.5	3.1	2.7	2.3	1.9	1.5	1.2
12-18 in	6.0	5.5	5.0	4.5	4.0	3.5	3.0	2.5	2.0	1.5
18-24 in					-	5.0	4.3	3.6	2.9	2.1
24-30 in										-
				36-in root zone						
0 - 1 ft	4.7	4.3	3.9	3.5	3.1	2.7	2.4	2.0	1.6	1.2
1 - 2 ft	7.1	6.5	5.9	5.3	4.7	4.1	3.5	2.9	2.4	1.8
2 - 3 ft								-	5.3	4.0
				42-in root zone						
0 - 1 ft	5.3	4.9	4.4	4.0	3.6	3.1	2.7	2.2	1.8	1.3
1 - 2 ft	7.5	6.9	6.3	5.6	5.0	4.4	3.8	3.1	2.5	1.9
2 - 3 ft					-	7.4	6.3	5.3	4.2	3.2
3-3.5 ft										-
				48-in root zone						
0 - 1 ft	6.0	5.5	5.0	4.5	4.0	3.5	3.0	2.5	2.0	1.5
1 - 2 ft	8.0	7.3	6.7	6.0	5.3	4.7	4.0	3.3	2.7	2.0
2 - 3 ft		-	10.0	9.0	8.0	7.0	6.0	5.0	4.0	3.0
3 - 4 ft									-	5.0

	Available Moisture (AM) in inches per foot									
	2.4	2.2	2.0	1.8	1.6	1.4	1.2	1.0	0.8	0.6
				54-in root zone						
0-1 ft	6.7	6.1	5.6	5.0	4.4	3.9	3.3	2.8	2.2	1.7
1-2 ft	8.6	7.9	7.2	6.4	5.7	5.0	4.3	3.6	2.9	2.1
2-3 ft	-	10.5	9.5	8.6	7.6	6.7	5.7	4.8	3.8	2.9
3-4 ft							-	8.3	6.6	5.0
4-4.5 ft										-
				5-ft root zone						
0-1 ft	7.3	6.7	6.1	5.5	4.9	4.3	3.6	3.0	2.4	1.8
1-2 ft	9.2	8.5	7.7	6.9	6.2	5.4	4.5	3.9	3.1	2.3
2-3 ft	-	11.0	10.0	9.0	8.0	7.0	6.0	5.0	4.0	3.0
3-4 ft					-	10.0	8.6	7.1	5.7	4.3
4-5 ft										-
				6-ft root zone						
0-2 ft	9.4	8.6	7.9	7.1	6.3	5.5	4.7	3.9	3.1	2.4
2-4 ft	14.1	12.9	11.8	10.6	9.4	8.2	7.1	5.9	4.7	3.5
4-6 ft								-	10.7	8.0
				7-ft root zone						
0-2 ft	10.7	9.8	8.9	8.0	7.1	6.2	5.3	4.4	3.6	2.7
2-4 ft	15.0	13.7	12.5	11.2	10.0	8.8	7.5	6.3	5.0	3.8
4-6 ft					-	14.8	12.7	10.5	8.4	6.3
				8-ft root zone						
0-2 ft	12.0	11.0	10.0	9.0	8.0	7.0	6.0	5.0	4.0	3.0
2-4 ft	16.0	14.7	13.3	12.0	10.7	9.3	8.0	6.7	5.3	4.0
4-6 ft			-	18.0	16.0	14.0	12.0	10.0	8.0	6.0
6-8 ft									-	12.0
				9-ft root zone						
0-2 ft	13.3	12.2	11.1	10.0	8.9	7.8	6.7	5.6	4.5	3.3
2-4 ft	17.2	15.7	14.3	12.9	11.4	10.0	8.6	7.1	5.7	4.3
4-6 ft	-	20.9	19.0	17.1	15.2	13.3	11.4	9.5	7.6	5.7
6-8 ft								-	13.4	10.0
8-9 ft										--
				10-ft root zone						
0-2 ft	14.6	13.4	12.1	10.9	9.7	8.5	7.3	6.1	4.9	3.6
2-4 ft	18.5	16.9	15.4	13.9	12.3	10.8	9.2	7.7	6.2	4.6
4-6 ft	-	22.0	20.0	18.0	16.0	14.0	12.0	10.0	8.0	6.0
6-8 ft						20.0	17.2	14.3	11.5	8.6
8-10 ft										-

NOTE: Values below line are not limiting; used only to obtain average value where texture changes occur within an indicated layer.

* Reference: Capacity of Soil to Hold Moisture. Dale R. Shockley. Agricultural Engineering, February, 1955.

The TRAM values for the various root zone soil profiles do not provide any safety factor to compensate for innaccuracy of soil moisture determinations or for a possible time lag before irrigation water is applied. Knowing the TRAM value for a given root zone soil profile, this value should be discounted by about one inch in recommendations for frequency of irrigation water application. This will allow a safety factor of from 3 to 5 crop growth days. An example of how to use table 3 to determine the TRAM value follows: Assume a loam surface soil the 0 - 1 foot depth with an AM value of 1.8. The soils below this depth are of a heavier texture with a higher water holding capacity of AM value. The crop growing on the loam soil has a mature root system extending to a 4 foot depth. Entering table 3 at the upper part of the table and at 1.8 reading down to the 48' or 4' root zone across from the 0 - 1' layer we find this value 4.5. Following the recommendations, we subtract 1" from this value obtaining a 3.5" TRAM value modified with a factor of safety.

Where the available moisture is known for each foot of depth of a soil profile, the TRAM value can be determined by the above procedure.

AGRONOMIC

The value of maintaining suitable moisture conditions for irrigated crops has been adequately proven by research. The proper irrigation of the various crops can be insured by numerous methods. Foremost of these is the Irrigation Gauge followed by the feel method or ball test method of determining soil moisture conditions.

The following information has been taken from literature published by the Lethbridge Research Station ("Irrigation Farming in Southern Alberta" by K. W. Hill and A. E. Palmer). (2) This information is included to make available general recommendations for irrigations.

Alfalfa

"A good supply of moisture is essential to the establishment of a satisfactory stand of alfalfa. Irrigation applications should be made to suit the alfalfa rather than the nurse crop, — when alfalfa is seeded with a cereal nurse crop it is necessary to irrigate more frequently than for a grain crop alone. Alfalfa has a very high water consumption. To produce a pound of dry matter, it requires more than twice as much water as corn or sugar beets.

At the Experimental Station best yields of hay were obtained by applying three 6-inch irrigations, respectively, as follows:

(1) early in May
(2) when the crop was 12 inches high

(3) immediately after the first cutting.
The yield was only slightly less when the early May irrigation was replaced by an application the previous fall. It is the usual practice to irrigate shortly before or immediately after the first crop of hay is cut in order to stimulate the growth of the second crop. In general, it is felt that irrigating shortly before the first crop is cut provides for a quicker resumption of growth of the second crop. However, if the soil is unduly wet at cutting time, some difficulty in curing may be encountered." (2)

Recent investigations by Hobbs, E. H., et al., (3) has indicated that the desirable moisture conditions for best economic returns from alfalfa is to maintain readily available moisture at 40 to 100% of total moisture available.

Sugar Beets

Sugar beets have a high water requirement, and it is important that the crop be well supplied with moisture throughout the entire growing season. Frequent light irrigations are more effective than heavy irrigations at longer intervals. Enough water should be supplied at each irrigation to connect up with the moist subsoil. At the Lethbridge Experimental Station, best yields of beets have been obtained with three or four irrigations in addition to an irrigation the previous fall. Irrigations should be begun soon after thinning and repeated at two- or three-week intervals during the growing season so that the soil is kept moist at all times and the beets are maintained in an active growing condition. The last irrigation should be timed to leave the soil moist for harvesting. This not only makes harvesting easier, but decidedly increases yields and improves the storing quality of the beets.

In Alberta, sugar beets are irrigated by the furrow method. For best results the length of runs between cross ditches should be 100 to 150 yards depending on the slope of the land." (2)

Additional studies by Hobbs, E. H., et al., (3) have indicated that sugar beets should be maintained at moisture conditions of 25 to 100% total readily available moisture. This is one crop that can be allowed a wider range of moisture conditions.

Potatoes

"Potatoes require very careful irrigation. The potato crop does not need so much water to produce a ton of dry matter as alfalfa or sugar beets, but with potatoes the amount and time of application are much more exacting.

When should potatoes be irrigated? Potato plants should be kept in an active growing condition from emergence until harvest approaches. Any cessation of rapid growth even for short periods will be reflected either in reduced yield or lowered quality.

This makes it necessary to apply irrigation water whenever the plants need it, before they show any signs of suffering from lack of moisture. A dry period during the first few weeks of growth, when the plants are small, will result in small vines with limited leaf area. It is essential to have large vines to ensure maximum food manufacturing capacity if high yields are to be obtained. A shortage of moisture at the time the tubers are being set is particularly objectionable. If fields are dry at this time, a reduced number of tubers will be set, and if additional moisture is subsequently supplied, these tubers are likely to grow into large, rough potatoes.

Method and Amount of Irrigation - Potatoes are irrigated by running small streams of water down furrows between the rows. With potatoes, as with other row crops, more thorough and precise irrigation is possible if the rows run down a very gentle slope. One to two inches of fall per 100 feet is ideal. In medium to heavy soil irrigation furrows should be deep and narrow so that the water will not cause a saturated condition to the soil immediately around the tubers. In sandy soils the furrows are more satisfactory if they are shallower and wider thus bringing the water closer to the vines. The lateral movement of water is much greater in heavy soils than in light soils.

The length of time the water should be left running in a furrow depends upon the rate of percolation, slope of land, moisture content of soil, stage of plant growth, etc. Potatoes receive more than half their water requirements from the top 12 inches of soil, and more than three-quarters from the top 24 inches. This stresses the need of keeping the surface layers of soil well supplied with moisture, which necessitates frequent, light irrigations. At the Experimental Station, Lethbridge, on medium loam soils, it has been found necessary to irrigate, as lightly as possible, about every three weeks during the active growing season, extending or shortening the period between irrigations to compensate for rains or very dry spells." (2)

Irrigated Pastures

"Pasture production under irrigation is particularly favorably adapted since generous application of water during the hot summer months maintains pasture at full production. In humid regions, where irrigation is not used, there frequently occurs a decided drop-off in pasturage during mid-summer. Rotational grazing makes it possible to irrigate pastures frequently and still allows sufficient time for the surface soil to dry before the stock are turned in.

Lush, rapidly growing forage plants have a high water requirement. Under Alberta conditions high-producing pastures will need about 18 inches of supplemental water per season. This is best applied in relatively small amounts and the usual

practice is to irrigate a paddock as soon as the stock have been removed after grazing it down. Three or four irrigations per year are the usual number. Sprinkler irrigation is well adapted to pasture and by this means lighter amounts at more frequent intervals can be applied." (2)

Canning Peas

"It is essential that peas be maintained in an actively-growing, lush condition if a high quality canning product is to be produced. This means that adequate moisture must be supplied. At seeding time the land should contain sufficient moisture to germinate the seed and bring the crop along to a height of 6 or 8 inches. At this stage the ground will be shaded and the young plants will respond to an irrigation. A second irrigation shortly before harvesting will assist materially in producing green peas of good quality. Uniform irrigation is indispensable. Unirrigated spots or low areas where the water ponds produce no peas." (2)

Canning Corn

"On a hot, windy day an acre of corn will use up an acre-inch of water. Water should be applied early enough to ensure that the plants do not suffer. On medium textured soils it is common practice to irrigate when the plants are one to two feet high and again about at the silking stage. An application of water a few days prior to picking improves the quality and weight of the crop." (2)

Cereal Grains

"In Southern Alberta one application of about 6 inches of water will often produce a good yield of cereal grains. In extensive studies at Lethbridge, however, best yields of wheat were obtained with three applications, at 5-leaf, shot-blade, and flowering stages, or two applications, at 5-leaf and flowering stages; one irrigation at shot-blade stage produced only a slightly lower yield. These studies showed that grain should be irrigated before the supply of moisture becomes short. Contrary to popular belief, there was no ill effect from irrigating in the three-leaf stage before the plants shaded the ground.

It is not advisable to irrigate a heavy grain crop after it is in head as this predisposes the grain to lodging. Barley and oats lodge more readily than wheat, and because of this, many farmers have grown wheat rather than barley for feed grain." (2)

REFERENCES

(1) Method for Evaluating Irrigation Systems:

Agriculture Handbook - No. 82 - Soil, Conservation Service, United States Department of Agriculture.

(2) Irrigation Farming in Southern Alberta:

K. W. Hill and A. E. Palmer,
Publication 883, March 1953,
Department of Agriculture, Ottawa,
CANADA.

(3) Effects of Levels of Minimum Available Soil Moisture on Crop Yields:

Hobbs, E. H., K. K. Krogman, and L. G. Sonmor, Canadian Journal of Plant Science 43: 441 - 446, October, 1963.

Table 7 - Soils (Chin-Lethbridge)		Crops					Irrigation Specifications							
Profile Description	Available Moisture Holding Capacity (in.)	Locally Adapted Crops	Root Zone Depth (ft.)	Net Moisture to be replaced each irrigation (in.)	Peak Period Consumptive Use Rate (in./day)	Irrigation Frequency during maximum consumptive use (days)	Added conservation irrigation methods	Basic Intake Rate, borders, flooding & sprinkling (in/hr) furrow & corrugation (gpm/100 ft)	Average stream size border & flooding unit stream (cfs) furrow & corrugation (maximum stream) gpm	Border width (ft) furrow & corrugation spacings (in.)	Length of run (ft.)	Estimated field efficiency (%)	Gross irrigation application (in.)	Estimated time required (hours)
						Slope 0.20 - 0.50%								
Loam to silt loam soils of alluvial or alluvial lacustrine deposition Moderately permeable. Medium to heavy lime carbonate accumulation 17-30 inches from surface.	(0-1) 1.9 (1-2) 1.95 (2-3) 2.00 (3-4) 2.00	Alfalfa	4.0	3.80	0.21	18	Borders Sprinklers	0.75 0.75	.0075	50	1800	80 75	4.75 5.1	1.45 -
		Small Grains	4.0	3.80	0.20	19	Borders Sprinklers	0.75 0.75	.0075	50	1800	80 75	4.75 5.1	1.45 -
		Grass	3.0	3.25	0.23	14	Borders Sprinklers	0.75 0.75	.0081	50	2250	80 75	4.1 4.3	1.15 -
		Peas	3.0	3.00	0.21	14	Borders Sprinklers	0.75 0.50	.0086	50	1600	80 75	3.75 4.0	1.0 -
		Sugar Beets	4.0	3.80	0.21	18	Furrows Sprinklers	1.3 0.5	25	22	925	70 75	5.4 5.1	6.9 -
		Corn	4.0	3.80	0.19	20	Furrows Sprinklers	1.3 0.5	25	36	925	70 75	5.4 5.1	11.4 -
		Potatoes	4.0	3.30	0.21	16	Furrows Sprinklers	1.4 0.50	25	30-36	860	70 ,75	4.7 4.4	9.2 -
		Beans	4.0	3.80	0.20	19	Furrows Sprinklers	1.3 0.5	25	30	925	70 75	5.4 5.1	9.5 -

NOTE: Lengths with slopes under 0.5% may be governed by allowable depth of flow

Soils - (Chin-Lethbridge)		Crops					Irrigation Specifications							
Profile Description	Available Moisture Holding Capacity (in.)	Locally Adapted Crops	Root Zone Depth (ft.)	Net Moisture to be replaced each irrigation (in.)	Peak Period Consumptive Use Rate (in/day)	Irrigation Frequency during maximum consumptive use (days)	Added conservation irrigation methods	Basic Intake Rate, borders, flooding & sprinkling (in/hr) furrow & corrugation (gpm/100 ft)	Average stream size border & flooding unit stream (cfs) furrow & corrugation (max. stream) gpm	Border width (ft) furrow & corrugation spacings (in.)	Length of run (ft.)	Estimated field efficiency (%)	Gross irrigation application (in.)	Estimated time required (hours)
						Slope	Group 0.5 -	1.0 %						
Moderately permeable, dark brown loam to silt loam soils. Medium to heavy lime carbonate content 17 to 30 inches from soil surface.	(0-1) 1.9 (1-2) 1.9 (2-3) 2.0 (3-4) 2.0	Alfalfa	4.0	3.80	0.21	18	Borders	0.75	.0063	40	1250	75	5.1	1.9
							Sprinklers	0.75				75	5.1	-
							Corrugation	0.90	13	24	750	65	5.8	14.0
		Small Grains	4.0	3.80	0.20	19	Borders	0.75	.0063	40	1250	75	5.1	1.9
							Sprinklers	0.75				75	5.1	-
							Corrugation	1.0	13	20	600	65	5.8	10.0
		Grass	3.0	3.25	0.23	14	Borders	0.75	.0068	40	1500	75	4.3	1.45
							Sprinklers	0.75				75	4.3	-
							Corrugation	1.0	13	20	550	65	5.0	7.0
		Peas	3.0	3.00	0.21	14	Borders	0.75	.0072	40	1050	75	4.0	1.3
							Sprinklers	0.50				75	4.0	-
		Sugar Beets	4.0	3.80	0.21	18	Furrows	1.0	16	22	650	65	5.8	9.0
							Sprinklers	0.5				75	5.1	-
		Corn	4.0	3.80	0.19	20	Furrows	1.0	16	36	650	65	5.8	14.8
							Sprinklers	0.5				75	5.1	-
		Potatoes	4.0	3.30	0.21	16	Furrows	1.1	16	36	610	65	5.1	11.7
							Sprinklers	0.5				75	4.4	-
		Beans	4.0	3.80	0.20	19	Furrows	1.0	16	30	650	65	5.8	12.3
							Sprinklers	0.5				75	5.1	-

Soils - (Chin-Lethbridge)		Crops					Irrigation Specifications							
Profile Description	Available Moisture Holding Capacity (in.)	Locally Adapted Crops	Root Zone Depth (ft.)	Net Moisture to be replaced each irrigation (in.)	Peak Period Consumptive Use Rate (in./day)	Irrigation Frequency during maximum consumptive use (days)	Added conservation irrigation methods	Basic Intake Rate, borders, flooding & sprinkling (in/hr) furrow & corrugation (gpm/100 ft)	Average stream size border & flooding unit stream (cfs) furrow & corrugation (max. stream) gpm	Border width (ft) furrow & corrugation spacings (in.)	Length of run (ft.)	Estimated field efficiency (%)	Gross irrigation application (in.)	Estimated time required (hours)
						Slope Group 1.0 - 2.0%								
		Alfalfa	4.0	3.80	0.21	18	Borders Sprinklers Corrugation C D	0.75 0.75 0.7 0.75	.0053 8 .0053	33 20	840 460 175	75 75 60 55	5,1 5.1 6.3 6.9	2.2 - 11.7 4.5
		Small Grains	4.0	3.80	0.20	19	Borders Sprinklers Corrugation C D	0.75 0.75 0.7 0.75	.0053 8 .0053	33 20	840 460 175	75 75 60 55	5.1 5.1 6.3 6.9	2.2 - 11.7 4.5
		Grass	3.0	3.25	0.23	14	Borders Sprinklers Corrugation C D	0.75 0.75 0.8 0.75	.0058 8 .0058	33 20	1050 415 175	75 75 60 55	4.3 4.3 5.4 5.9	1.7 - 8.7 4.1
		Peas	3.0	3.00	0.21	14	Borders Sprinklers Corrugation C D	0.75 0.5 0.8 0.75	.0061 8 .0061	33 20	730 400 175	75 75 60 55	4.0 4.0 5.0 5.5	1.5 - 8.1 3.8
		Sugar Beets	4.0	3.80	0.21	18	Furrows Sprinklers	0.8 0.50	8	22	450	60 75	6.3 5.1	11.3 -
		Corn	4.0	3.80	0.19	20	Furrows Sprinklers	0.8 0.5	8	36	450	60 75	6.3 5.1	18.5 -
		Potatoes	4.0	3.30	0.21	16	Furrows Sprinklers	0.9 0.5	8	36	420	60 75	5.1 4.4	14.3 -
		Beans	4.0	3.80	0.20	19	Furrows Sprinklers	0.8 0.5	8	30	450	60	6.3	15.3

Soils - (Chin-Lethbridge)		Crops					Irrigation Specifications							
Profile Description	Available Moisture Holding Capacity (in.)	Locally Adapted Crops	Root Zone Depth (ft.)	Net Moisture to be replaced each irrigation (in.)	Peak Period Consumptive Use Rate (in./day)	Irrigation Frequency during maximum consumptive use (days)	Added conservation irrigation methods	Basic Intake Rate, borders, flooding & sprinkling (in/hr) furrow & corrugation (gpm/100 ft)	Average stream size border & flooding unit stream (cfs) furrow & corrugation (max. stream) gpm	Border width (ft) furrow & corrugation spacings (in.)	Length of run (ft.)	Estimated field efficiency (%)	Cross irrigation application (in.)	Estimated time required (hours)
		Slope - 2.0 - 4.0%												
		Alfalfa	4.0	3.80	0.21	18	Sprinkler	0.75				75	5.1	-
							Corrugation	0.5	4	20	300	55	6.9	16.4
							C D	0.75	.0069*		125	55	6.9	4.5
		Small Grains	4.0	3.80	0.20	19	Sprinkler	0.75				75	5.1	-
							Corrugation	0.5	4	20	300	55	6.9	16.4
							C D	0.75	.0069*		125	55	6.9	4.5
		Grass	3.0	3.25	0.23	14	Sprinkler	0.75				75	4.3	-
							Corrugation	0.6	4	20	290	55	5.9	11.5
							C D	0.75	.0069*		125	55	5.9	4.1
		Peas	3.0	3.00	0.21	14	Sprinkler	0.5				75	4.0	-
							Corrugation	0.6	4	20	275	55	5.5	10.7
							C D	0.75	.0069*		125	55	5.5	3.8
		Sugar Beets	4.0	3.80	0.21	18	Furrow	0.6	4	22	305	55	6.9	15.0
							Sprinkler	0.5				75	5.1	-
		Corn	4.0	3.80	0.19	20	Furrow	0.6	4	36	305	55	6.9	24.6
							Sprinkler	0.5				75	5.1	-
		Potatoes	4.0	3.30	0.21	16	Furrow	0.7	4	36	280	55	6.0	18.3
							Sprinkler	0.5				75	4.4	-
		Beans	4.0	3.80	0.20	19	Furrow	0.6	4	30	305	55	6.9	20.5

Soils - (Chin-Lethbridge)		Crops					Irrigation Specifications							
Profile Description	Available Moisture Holding Capacity (in.)	Locally Adapted Crops	Root Zone Depth (ft.)	Net Moisture to be replaced each irrigation (in.)	Peak Period Consumptive Use Rate (in./day)	Irrigation Frequency during maximum consumptive use (days)	Added conservation irrigation methods	Basic Intake Rate, borders, flooding & sprinkling (in./hr) furrow & corrugation (gpm/100 ft)	Average stream size border & flooding unit stream (cfs) furrow & corrugation (max. stream) gpm	Border width (ft) furrow & corrugation spacings (in.)	Length of run (ft.)	Estimated field efficiency (%)	Gross irrigation application (in.)	Estimated time required (hours)
						Slope	Group 4.0 -	8.0%						
		Alfalfa	4.0	3.80	0.21	18	Corrugation	0.45	2	20	240	50	7.6	18.1
							Sprinklers	0.75				75	5.1	-
							C. Ditch	0.75	.0099*		75	50	7.6	4.5
		Small Grains	4.0	3.80	0.20	19	Corrugation	0.45	2	20	240	50	7.6	18.1
							Sprinkler	0.75				75	5.1	-
							C. Ditch	0.75	.0099*		75	50	7.6	4.5
		Grass	3.0	3.25	0.23	14	Corrugation	0.55	2	20	220	50	6.5	12.6
							Sprinkler	0.75				75	4.3	-
							C. Ditch	0.75	.0099*		75	50	6.5	4.10
		Peas	3.0	3.00	0.21	14	Corrugation	0.55	2	20	200	50	6.0	11.6
							Sprinkler	0.50				75	4.0	-
							C. Ditch	0.75	.0099*		75	50	6.0	3.8
		Sugar Beets	4.0	3.80	0.21	18	Sprihkler	0.50				75	5.1	-
		Corn	4.0	3.80	0.19	20	Sprinkler	0.50				75	5.1	-
		Potatoes	4.0	3.30	0.21	16	Sprinkler	0.50				75	4.4	-
		Beans	4.0	3.80	0.20	19	Sprinkler	0.50				75	5.1	-

* Minimum spreading stream

Table 7 (Continued)

Soils -(Cavendish & Carmangay)		Crops					Irrigation Specifications							
Profile Description	Available Moisture Holding Capacity (in.)	Locally Adapted Crops	Root Zone Depth (ft.)	Net Moisture to be replaced each irrigation (in.)	Peak Period Consumptive Use Rate (in./day)	Irrigation Frequency during maximum consumptive use (days)	Added conservation irrigation methods	Basic Intake Rate, borders, flooding & sprinkling (in/hr) furrow & corrugation (gpm/100 ft)	Average stream size border & flooding unit stream (cfs) furrow & corrugation (max. stream) gpm	Border width (ft) furrow & corrugation spacings (in.)	Length of run (ft.)	Estimated field efficiency (%)	Gross irrigation application (in.)	Estimated time required (hours)
						Slope Group 0.2 - 0.5%								
dLS, FSL, SL apid permeability ow organic content ow salt content rown Sandy Loam ver yellowish rown sandy loam o loamy sand	(0-1) 1.5 (1-2) 1.8 (2-3) 1.85 (3-4) 2.0	Alfalfa	5	3.40	0.22	15	Border Sprinkler	1.0 1.0	.011	50	1300	75 75	4.5 4.5	0. -
		Small Grain	4	3.00	0.24	14	Border Sprinkler	1.0 1.0	.0116	50	1250	75 75	4.0 4.0	0. -
		Grass	3	2.60	0.23	11	Border Sprinkler	1.0 1.0	.0123	50	1470	75 70	3.48 3.70	0. -
		Peas	3	2.35	0.22	10	Border Sprinkler	1.0 0.8	.0127	50	1100	75 70	3.14 3.4	0. -
		Sugar Beets	4	3.00	0.22	13	Furrow Sprinkler	1.9 0.8	25	22	775	70 70	4.3 4.3	3. -
		Corn	4	3.00	0.20	15	Furrow Sprinkler	1.9 0.8	25	36	775	70 70	4.3 4.3	6. -
		Potatoes	4	2.50	0.22	11	Furrow Sprinkler	2.1 0.8	25	36	700	70 70	3.6 3.6	4. -
		Beans	4	3.00	0.21	14	Furrow Sprinkler	1.9 0.8	25	30	775	70 70	4.3 4.3	5. -

NOTE: Lengths with slopes under 0.5% may be governed by allowable depth of flow.

Soils -(Cavendish & Carmangay)		Crops					Irrigation Specifications							
Profile Description	Available Moisture Holding Capacity (in.)	Locally Adapted Crops	Root Zone Depth (ft.)	Net Moisture to be replaced each irrigation (in.)	Peak Period Consumptive Use Rate (in./day)	Irrigation Frequency during maximum consumptive use (days)	Added conservation irrigation methods	Basic Intake Rate, borders, flooding & sprinkling (in/hr) furrow & corrugation (gpm/100 ft)	Average stream size border & flooding unit stream (cfs) furrow & corrugation (max. stream) gpm	Border width (ft) furrow & corrugation spacings (in.)	Length of run (ft.)	Estimated field efficiency (%)	Gross irrigation application (in.)	Estimated time required (hours)
CdLs, FSL, SL Brown, sandy loam over yellowish brown sandy loam to loamy sand Rapid permeability Low organic content Low salt content	(0-1) 1.5 (1-2) 1.8 (2-3) 1.85 (3-4) 2.0					Slope Group 0.5 - 1.0%								
		Alfalfa	5	3.40	0.22	15	Border	1.0	.0092	40	820	70	4.9	1.24
							Sprinkler	1.0				75	4.5	-
							Corrugations	1.0	13	24	650	65	5.2	10.0
		Small Grain	4	3.00	0.21	14	Border	1.0	.0097	40	780	70	4.3	1.0
							Sprinkler	1.0				75	4.0	-
							Corrugation	1.0	13	20	500	65	4.6	6.0
		Grass	3	2.60	0.23	11	Border	1.0	.0103	40	1030	70	3.7	0.8
							Sprinkler	1.0				70	3.7	-
							Corrugation	1.0	13	20	450	65	4.0	5.0
		Peas	3	2.35	0.22	10	Border	1.0	.0106	40	700	70	3.4	0.75
							Sprinkler	0.8				70	3.4	-
		Sugar Beets	4	3.00	0.22	13	Furrow	1.4	16	22	550	65	4.6	5.1
							Sprinkler	0.8				70	4.3	-
		Corn	4	3.00	0.20	15	Furrow	1.4	16	36	550	65	4.6	8.3
							Sprinkler	0.8				70	4.3	-
		Potatoes	4	2.50	0.22	11	Furrow	1.6	16	36	500	65	3.8	6.1
							Sprinkler	0.8				70	3.6	-
		Beans	4	3.00	0.21	14	Furrow	1.4	16	30	550	65	4.5	6.9
							Sprinkler	0.8				70	4.3	-

Soils -(Cavendish & Carmangay)		Crops					Irrigation Specifications							
Profile Description	Available Moisture Holding Capacity (in.)	Locally Adapted Crops	Root Zone Depth (ft.)	Net Moisture to be replaced each irrigation (in.)	Peak Period Consumptive Use Rate (in./day)	Irrigation Frequency during maximum consumptive use (days)	Added conservation irrigation methods	Basic Intake Rate, borders, flooding & sprinkling (in/hr) furrow & corrugation (gpm/100 ft)	Average stream size border & flooding unit stream (cfs) furrow & corrugation (max. stream) gpm	Border width (ft) furrow & corrugation spacings (in.)	Length of run (ft.)	Estimated field efficiency (%)	Gross irrigation application (in.)	Estimated time required (hours)
							Slope Group 1.0 -	2.0%						
CdLS, FSL, SL Brown sandy loam over yellowish brown sandy loam Rapid permeability Low organic content Low salt content	(0-1) 1.5 (1-2) 1.8 (2-3) 1.85 (3-4) 2.0	Alfalfa	5	3.40	0.22	15	Borders	1.0	.0078	33	560	70	4.9	1.5
							Sprinklers	1.0				75	4.5	-
							Corrugation	1.05	8	20	400	60	5.7	7.0
							C D	1.0	.0078		150	55	6.2	3.2
		Small Grain	4	3.00	0.21	14	Borders	1.0	.0082	33	540	70	4.3	1.2
							Sprinklers	1.0				75	4.0	-
							Corrugation	1.10	8	20	375	60	5.0	6.0
							C D	1.0	.0082		150	55	5.5	2.7
		Grass	3	2.60	0.23	11	Borders	1.0	.0087	33	700	70	3.7	1.0
							Sprinklers	1.0				70	3.7	-
							Corrugation	1.25	8	18	340	60	4.3	4.0
							C D	1.0	.0087		150	55	4.7	2.0
		Peas	3	2.35	0.22	10	Borders	1.0	.009	33	500	70	3.4	0.9
							Sprinklers	0.8				70	3.4	-
							Corrugation	1.30	8	18	320	60	3.9	3.5
							C D	1.0	.009		150	55	4.31	1.7
		Sugar Beets	4	3.00	0.22	13	Furrow	1.1	8	22	375	60	5.0	6.5
							Sprinklers	0.8				70	4.3	-
		Corn	4	3.00	0.20	15	Furrow	1.1	8	36	375	60	5.0	10.
							Sprinklers	0.8				70	4.3	-
		Potatoes	4	2.50	0.22	11	Furrow	1.3	8	36	340	60	3.8	7.5
							Sprinklers	0.8				70	3.6	-
		Beans	4	3.00	0.21	14	Furrow	1.1	8	30	375	60	5.0	8.8
							Sprinkler	0.8				70	4.3	-

Soils - (Cavendish & Carmangay)		Crops					Irrigation Specifications							
Profile Description	Available Moisture Holding Capacity (in.)	Locally Adapted Crops	Root Zone Depth (ft.)	Net Moisture to be replaced each irrigation (in.)	Peak Period Consumptive Use Rate (in./day)	Irrigation Frequency during maximum consumptive use (days)	Added conservation irrigation methods	Basic Intake Rate, borders, flooding & sprinkling (in/hr) furrow & corrugation (gpm/100 ft)	Average stream size border & flooding unit stream (cfs) furrow & corrugation (max. stream) gpm	Border width (ft) furrow & corrugation spacings (in.)	Length of run (ft.)	Estimated field efficiency (%)	Gross irrigation application (in.)	Estimated time required (hours)
						Slope Group 2.0 - 4.0%								
CdLs, SL, FSL Brown sandy loam over yellowish brown sandy loam to loamy sand. Rapid permeability. Low organic content. Low salt content.	(0-1) 1.5 (1-2) 1.8 (2-3) 1.85 (3-4) 2.0	Alfalfa	5	3.40	0.22	15	Sprinklers	1.0				75	4.5	-
							Corrugation	0.85	4	20	265	55	6.2	8.6
							C D	1.0	.0069 *		100	55	6.2	3.2
		Small Grain	4	3.00	0.21	14	Sprinklers	1.0				70	4.3	-
							Corrugation	0.9	4	20	250	55	5.5	7.1
							C D	1.0	,0069 *		100	55	5.5	2.7
		Grass	3	2.60	0.23	11	Sprinklers	1.0				70	3.7	-
							Corrugation	1.0	4	18	230	55	4.7	5.9
							C D	1.0	.0069 *		100	55	4.7	2.0
		Peas	3	2.35	0.22	10	Sprinkler	0.8				70	3.4	-
							Corrugation	1.1	4	18	215	55	4.3	4.1
							C D	1.0	.0069 *		100	55	4.3	1.7
		Sugar Beets	4	3.00	0.22	13	Furrow	0.9	4	22	250	55	5.5	7.9
							Sprinkler	0.8				70	4.3	-
		Corn	4	3.00	0.20	15	Furrow	0.9	4	36	250	55	5.5	12.9
							Sprinkler	0.8				70	4.3	-
		Potatoes	4	2.50	0.22	11	Furrow	1.0	4	36	225	55	4.5	9.7
							Sprinkler	0.8				70	3.6	-
		Beans	4	3.00	0.21	14	Furrow	0.9	4	30	250	55	5.5	10.8
							Sprinkler	0.8				70	4.3	-

* Minimum spreading stream

Soils -(Cavendish & Carmangay)		Crops					Irrigation Specifications							
Profile Description	Available Moisture Holding Capacity (in.)	Locally Adapted Crops	Root Zone Depth (ft.)	Net Moisture to be replaced each irrigation (in.)	Peak Period Consumptive Use Rate (in./day)	Irrigation Frequency during maximum consumptive use (days)	Added conservation irrigation methods	Basic Intake Rate, borders, flooding & sprinkling (in/hr) furrow & corrugation (gpm/100 ft)	Average stream size border & flooding unit stream (cfs) furrow & corrugation (max stream) gpm	Border width (ft) furrow & corrugation spacings (in.)	Length of run (ft.)	Estimated field efficiency (%)	Gross irrigation application (in.)	Estimated time required (hours)
CdLs, SL, FSL Brown sandy loam over yellowish brown sandy loam to loamy sand. Rapid permeability Low organic content Low salt content						Slope Group 4.0 - 8.0%								
	(0-1) 1.5 (1-2) 1.8 (2-3) 1.85 (3-4) 2.0	Alfalfa	5.0	3.40	0.22	15	Corrugation	0.75	2	20	160	50	6,8	9.8
							Sprinkler	1.0				75	4.5	-
							C. Ditch	1.0	.0099 *		50	50	6.8	3.2
		Small Grain	4.0	3.00	0.21	14	Corrugation	0.8	2	20	175	50	6.0	8.1
							Sprinkler	1.0				70	4.3	-
							C. Ditch	1.0	.0099 *		50	50	6.0	2.7
		Grass	3.0	2.60	0.23	11	Corrugation	0.85	2	18	165	50	5.2	5.9
							Sprinkler	1.0				70	3.7	-
							C. Ditch	1.0	.0099 *		50	50	5.2	2.0
		Peas	3.0	2.35	0.22	10	Corrugation	0.9	2	18	160	50	4.7	5.1
							Sprinkler	0.8				70	3.4	-
		Sugar Beets	4.0	3.00	0.22	13	Sprinkler	0.8				70	4.3	-
		Corn	4.0	3.00	0.20	15	Sprinkler	0.8				70	4.3	-
		Potatoes	4.0	2.50	0.22	11	Sprinkler	0.8				70	3.6	-
		Beans	4.0	3.00	0.21	14	Sprinkler	0.8				70	4.3	-

* Minimum spreading stream

Table 7 (Continued)
Soils -(Coaldale)

		Crops					Irrigation Specifications							
Profile Description	Available Moisture Holding Capacity (in.)	Locally Adapted Crops	Root Zone Depth (ft)	Net Moisture to be replaced each irrigation (in.)	Peak Period Consumptive Use Rate (in./day)	Irrigation Frequency during maximum consumptive use (days)	Added conservation irrigation methods	Basic Intake Rate, borders, flooding & sprinkling (in/hr) furrow & corrugation (gpm/100 ft)	Average stream size border & flooding unit stream (cfs) furrow & corrugation (max. stream) gpm	Border width (ft) furrow & corrugation spacings (in.)	Length of run (ft.)	Estimated field efficiency (%)	Gross irrigation application (in.)	Estimated time required (hours)
						Slope Group 0.2 - 0.5%								
CdLeSiCL Orthic Dark Brown soils formed on fine textured Lacustrine parent material Very dark greyish brown silty clay loam in the "A" horizon. Has average organic matter content and is well supplied with mineral plant foods. It has a slow to very slow permeability rate. A medium lime layer accumulation appears at 16-24 inches from the surface	(0-1) 2.30 (1-2) 2.40 (2-3) 2.75 (3-4) 3.25	Alfalfa	4.0	4.6	.21	22	Border	0.5	.0038	50	2640	75	6.1	4.0
							Sprinkler	0.5				75	6.1	-
		Grass	3.0	4.0	.21	19	Border	0.5	.0042	50	2640	75	5.3	3.15
							Sprinkler	0.5				75	5.3	-
		Grain	4.0	4.6	.20	23	Border	0.5	.0038	50	2640	75	6.1	4.0
							Sprinkler	0.5				75	6.1	-
		Peas	3.0	3.5	.20	18	Border	0.5	.0045	50	2640	70	5.0	2.6
							Sprinkler	0.3				70	5.0	-
		Potatoes	4.0	4.1	.20	20	Furrow	1.0	25	36	1020	70	5.9	15.9
							Sprinkler	0.3				70	5.9	-
		Corn	4.0	4.6	.19	24	Furrow	0.95	25	36	1090	70	6.5	18,8
							Sprinkler	0.3				70	6.6	-
		Sugar Beets	4.0	4.60	.21	22	Furrow	0.95	25	22	1090	70	6.5	11.5
							Sprinkler	0.3				70	6.6	-
		Beans	4.0	4.6	.20	23	Furrow	0.95	25	30	1090	70	6.5	15.7
							Sprinkler	0.3				70	6.6	-

NOTE: Lengths with slopes under 0.5% may be governed by allowable depth of flow.

Soils -(Coaldale)		Crops					Irrigation Specifications								
Profile Description	Available Moisture Holding Capacity (in.)	Locally Adapted Crops	Root Zone Depth (ft.)	Net Moisture to be replaced each irrigation (in.)	Peak Period Consumptive Use Rate (in./day)	Irrigation Frequency during maximum consumptive use (days)	Added conservation irrigation methods	Basic Intake Rate, border & flooding & sprinkling (in/hr) furrow & corrugation (gpm/100 ft)	Average stream size border & flooding unit stream (cfs) furrow & corrugation (max. stream) gpm	Border width (ft) furrow & corrugation spacings (in)	Length of run (ft.)	Estimated field efficiency (%)	Gross irrigation application (in.)	Estimated time required (hours)
						Slope	0.5 - 1.0%							
	(0-1) 2.30 (1-2) 2.40 (2-3) 2.75 (3-4) 3.25	Alfalfa	4.0	4.6	.21	22	Border	0.5	.0032	40	2400	70	6.6	4.8
							Sprinkler	0.5				75	6.1	-
							Corrugation	0.6	13	24	900	65	7.1	20.0
		Grass	3.0	4.0	.21	19	Border	0.5	.0035	40	2640	70	5.7	3.8
							Sprinkler	0.5				70	5.3	-
							Corrugation	0.6	13	20	700	65	6.2	11.3
		Grain	4.0	4.6	.20	23	Border	0.5	.0032	40	2400	70	6.6	4.8
							Sprinkler	0.5				75	6.1	-
							Corrugation	0.6	13	20	700	65	7.1	16.0
		Peas	3.0	3.5	.20	18	Border	0.5	.0038	40	2000	70	5.0	3.1
							Sprinkler	0.3				70	5.0	-
		Potatoes	4.0	4.1	.20	20	Furrow	0.8	16	36	725	65	6.3	19.9
							Sprinkler	0.3				70	5.9	-
		Corn	4.0	4.6	.19	24	Furrow	0.75	16	36	760	65	7.1	23.8
							Sprinkler	0.3				70	6.6	-
		Sugar Beets	4.0	4.60	.21	22	Furrow	0.75	16	22	760	65	7.1	14.6
							Sprinkler	0.3				70	6.6	-
		Beans	4.0	4.6	.20	23	Furrow	0.75	16	30	760	65	7.1	19.9
							Sprinkler	0.3				70	6.6	-

Soils -(Coaldale)		Crops					Irrigation Specifications							
Profile Description	Available Moisture Holding Capacity (in.)	Locally Adapted Crops	Root Zone Depth (ft.)	Net Moisture to be replaced each irrigation (in.)	Peak Period Consumptive Use Rate (in./day)	Irrigation Frequency during maximum consumptive use (days)	Added conservation irrigation methods	Basic Intake Rate, borders, flooding & sprinkling (in/hr) furrow & corrugation (gpm/100 ft)	Average stream size border & flooding unit stream (cfs) furrow & corrugation (max. stream) gpm	Border width (ft) furrow & corrugation spacings (in.)	Length of run (ft.)	Estimated field efficiency (%)	Gross irrigation application (in.)	Estimated time required (hours(
						Slope Group 1.0 – 2.0%								
	(0-1) 2.30	Alfalfa	4.0	4.6	0.21	22	Border	0.5	.0049 *	33	880	55	8.4	7.2x
	)1-2) 2.40						Sprinkler	0.5				75	6.1	-
	(2-3) 2.75						Corrugation	.45	9	30	550	60	7.7	32.5
	(3-4) 3.25						C D	0.5	.0049 *		250	50	9.2	11.2
		Grass	3.0	4.0	0.21	19	Border	0.5	.0049 *	33	1170	55	7.3	5.6x
							Sprinkler	0.5				75	5.3	-
							Corrugation	0.5	9	24	500	60	6.7	20.0
							C D	0.5	.0049 *		250	50	8.0	9.4
		Grain	4.0	4.6	0.20	23	Border	0.5	.0049 *	33	880	55	8.4	7.2x
							Sprinkler	0.5				75	6.1	-
							Corrugation	0.45	9	30	550	60	7.7	32.5
							C D	0.5	.0049 *		250	50	9.2	11.2
		Peas	3.0	3.5	0.20	18	Border	0.5	.0049 *	33	880	60	5.8	4.2x
							Sprinkler	0.3				70	5.0	-
							Corrugation	0.5	9	24	460	60	5.8	18.0
							C D	0.5	.0049 *		250	50	7.0	7.8
		Potatoes	4.0	4.1	0.20	20	Furrow	0.6	9	36	500	60	6.3	26.6
							Sprinkler	0.3				70	5.9	-
		Corn	4.0	4.6	0.19	24	Furrow	0.55	9	36	525	60	7.7	32.5
							Sprinkler	0.3				70	6.6	-
		Sugar Beets	4.0	4.60	0.21	22	Furrow	0.55	9	22	525	60	7.7	19.9
							Sprinkler	0.3				70	6.6	-
		Beans	4.0	4.6	0.20	23	Furrow	0.55	9	30	525	60	7.7	27.0
							Sprinkler	0.3				70	6.6	-

* Minimum spreading stream

Soils -(Coaldale)		Crops					Irrigation Specifications							
Profile Description	Available Moisture Holding Capacity (in.)	Locally Adapted Crops	Root Zone Depth (ft.)	Net Moisture to be replaced each irrigation (in.)	Peak Period Consumptive Use Rate (in./day)	Irrigation Frequency during maximum consumptive use (days)	Added conservation irrigation methods	Basic Intake Rate, borders, flooding & sprinkling (in/hr) furrow & corrugation (gpm/100 ft)	Average stream size border & flooding unit stream (cfs) furrow & corrugation (max. stream) gpm	Border width (ft) furrow & corrugation spacings (in.)	Length of run (ft.)	Estimated field efficiency (%)	Gross irrigation application (in.)	Estimated time required (hours)
							Slope Group 2.0 - 4.0%							
	(0-1) 2.30 (1-2) 2.40 (2-3) 2.75 (3-4) 3.25	Alfalfa	4.0	4.6	0.21	22	Sprinkler Corrugation C. Ditch	0.5 0.4 0.5	 4 .0069 *	30	 375 200	75 55 50	6.1 8.4 9.2	- 36.0 12.0
		Grass	3.0	4.0	0.21	19	Sprinkler Corrugation C. Ditch	0.5 0.4 0.5	 4 .0069 *	24	 350 200	75 55 50	5.3 7.3 8.0	- 25.0 10.0
		Grain	4.0	4.6	0.20	23	Sprinkler Corrugation C. Ditch	0.5 0.4 0.5	 4 .0069 *	30	 375 200	75 55 50	6.1 8.4 9.2	- 36.0 12.0
		Peas	3.0	3.5	0.20	18	Sprinkler Corrugation C. Ditch	0.3 0.4 0.5	 4 .0069 *	24	 310 200	70 55 50	5.0 6.4 7.0	- 22.2 8.3
		Potatoes	4.0	4.1	0.20	20	Furrow Sprinkler	0.5 0.3	4	36	325	55 70	6.8 5.9	31.9 -
		Corn	4.0	4.6	0.19	24	Furrow Sprinkler	0.45 0.3	4	36	350	55 70	8.4 6.6	39.7 -
		Sugar Beets	4.0	4.60	0.21	22	Furrow Sprinkler	0.45 0.3	4	22	350	55 70	8.4 6.6	24.3 -
		Beans	4.0	4.6	0.20	23	Furrow Sprinkler	0.45 0.3	4	30	350	55 70	8.4 6.6	33.1 -

Soils -(Coaldale)		Crops					Irrigation Specifications							
Profile Description	Available Moisture Holding Capacity (in)	Locally Adapted Crops	Root Zone Depth (ft.)	Net Moisture to be replaced each irrigation (in.)	Peak Period Consumptive Use Rate (in./day)	Irrigation Frequency during maximum consumptive use (days)	Added conservation irrigation methods	Basic Intake Rate, border & flooding & sprinkling (in/hr) furrow & corrugation (gpm/100 ft)	Average stream size border & flooding unit stream (cfs) furrow & corrugation (max. stream) gpm	Border width (ft) furrow & corrugation spacings (in.)	Length of run (ft.)	Estimated field efficiency (%)	Gross irrigation application (in.)	Estimated time required (hours)
						Slope Group 4.0 - 8.0%								
	(0-1) 2.30 (1-2) 2.40 (2-3) 2.75 (3-4(3.25	Alfalfa	4.0	4.6	0.21	22	Corrugation	0.35	2	30	250	50	9.2	42.0
							Sprinkler	0.5				75	6.1	-
							C D	0.5	.0099 *		125	50	9.2	11.2
		Grass	3.0	4.0	0.21	19	Corrugation	0.35	2	24	225	50	8.0	29.2
							Sprinkler	0.5				75	5.3	-
							C D	0.5	.0099 *		125	50	8.0	9.4
		Grain	4.0	4.6	0.20	23	Corrugation	0.35	2	30	250	50	9.2	42.0
							Sprinkler	0.5				75	6.1	-
							C D	0.5	.0099 *		125	50	9.2	11.2
		Peas	3.0	3.5	0.20	18	Corrugation	0.35	2	24	215	50	7.0	25.8
							Sprinkler	0.3				70	5.0	-
							C D	0.5	.0099 *		125	50	7.0	7.8
		Potatoes	4.0	4.1	0.20	20	Sprinkler	0.3				70	5.9	-
		Corn	4.0	4.6	0.19	24	Sprinkler	0.3				70	6.6	-
		Sugar Beets	4.0	4.60	0.21	22	Sprinkler	0.3				70	6.6	-
		Beans	4.0	4.6	0.20	23	Sprinkler	0.3				70	6.6	-

* Minimum spreading stream